MDCAT TEST PREPARATION

BIOLOGY

Revision Guide — Strictly Mapped to the Official PMDC MDCAT 2025 Syllabus (Biology Section)

Every topic taken directly from PMDC's official MDCAT Biology curriculum

Explained in simple, exam-friendly language — like a teacher explaining to a 15-year-old

Key-fact boxes , MDCAT tips , common traps & quick-check MCQs

Covers all 16 Biology units — 81 MCQs (45% weightage) of the MDCAT paper

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Contents

Built unit-by-unit from PMDC's MDCAT 2025 Biology syllabus (Section 1)

How to use this book: Read each concept in plain language, lock in the key-facts box, dodge the trap box, note the MDCAT tip, and test yourself with the Quick Check MCQs at the end of every unit. This guide covers only topics listed in PMDC's official MDCAT 2025 Biology curriculum — nothing extra, nothing skipped.

1 Acellular Life

The tiniest 'living' things that aren't really alive on their own

PMDC Syllabus Unit 1 — Sub-topics: Viruses, AIDS and HIV Infection

What is a virus?

A virus is a tiny particle so small you need an electron microscope to see it — much smaller than a bacterium. It is called 'acellular' because it is NOT made of a cell — it has no cytoplasm, no organelles, and cannot carry out life processes on its own. A virus is simply genetic material (DNA or RNA) wrapped in a protein coat called a capsid. Outside a host cell, a virus is just a lifeless chemical particle; but once it enters a living cell, it hijacks the host's machinery to make thousands of new copies of itself.

Key Facts

Made of	Nucleic acid (DNA or RNA) + protein coat (capsid)
Classified by	Structure (helical, polyhedral, complex), number of nucleic acid strands, type of disease caused, and the host it infects (bacteria, plants, animals)
Living or non-living?	Neither — inactive outside a host cell, but 'takes over' and reproduces once inside one

AIDS and HIV

HIV (Human Immunodeficiency Virus) is the virus that causes AIDS (Acquired Immune Deficiency Syndrome). HIV attacks and destroys the body's helper T-cells (a type of white blood cell), which slowly cripples the immune system. This means a person with AIDS becomes extremely vulnerable to infections and cancers that a healthy immune system would easily fight off.

Key Facts

Symptoms	Persistent fever, weight loss, swollen lymph nodes, night sweats, and repeated infections as immunity collapses
Spread by	Unprotected sexual contact, sharing contaminated needles/ syringes, infected blood transfusions, and from mother to baby during pregnancy, birth, or breastfeeding
NOT spread by	Casual contact — shaking hands, hugging, sharing food, or mosquito bites

MDCAT Tip

MDCAT loves asking 'mode of transmission' questions. Remember: HIV spreads through body fluids (blood, semen, breast milk) — not through the air or casual touch.

60-Second Revision

- A virus = nucleic acid + protein coat; it is acellular and inactive outside a host
- Viruses are classified by structure, strand number, disease, and host
- HIV destroys helper T-cells, causing AIDS (collapse of the immune system)

• HIV spreads via blood, sexual contact, and mother-to-child — never by casual contact

Quick Check

1. A virus is best described as: A) A single cell B) Nucleic acid wrapped in a protein coat C) A bacterium D) A type of fungus
2. HIV mainly destroys which cells? A) Red blood cells B) Helper T-cells C) Platelets D) Skin cells
3. Which of these does NOT transmit HIV? A) Sharing needles B) Blood transfusion C) Shaking hands D) Mother to baby

Answers: 1-B, 2-B, 3-C

2

Bioenergetics

How your cells 'burn' food to release usable energy

PMDC Syllabus Unit 2 — Sub-topics: Respiration

Cellular respiration — burning more than just sugar

You already know glucose is broken down inside cells to release energy (ATP), mainly through glycolysis, the Krebs cycle, and the electron transport chain. But your body doesn't only run on carbohydrates — proteins and fats can also be respired for energy, especially when carbohydrate stores run low.

Key Facts

Fats → energy	Fats are first broken into fatty acids and glycerol. Glycerol is converted into an intermediate that enters glycolysis, while fatty acids are chopped into 2-carbon units that enter the Krebs cycle as Acetyl-CoA — the same entry point glucose uses.
Proteins → energy	Proteins are broken into amino acids. The amino (nitrogen-containing) part is removed first (a process called deamination), and the remaining carbon skeleton is converted into a Krebs-cycle intermediate or into pyruvate/Acetyl-CoA.
Common thread	Whether it starts as glucose, fat, or protein, everything eventually funnels into the Krebs cycle and electron transport chain to produce ATP.

MDCAT Tip

If a question mentions 'deamination' or 'removal of nitrogen', it's talking about protein respiration — that nitrogen waste is later excreted as urea by the kidneys (linking to the Homeostasis unit).

60-Second Revision

- Respiration isn't just about glucose — fats and proteins are respired too
- Fats: glycerol enters glycolysis; fatty acids enter as Acetyl-CoA
- Proteins: amino acids lose their nitrogen (deamination) before their carbon skeleton joins the Krebs cycle
- All pathways converge on the Krebs cycle and electron transport chain to make ATP

Quick Check

1. Fatty acids are converted into which molecule before entering the Krebs cycle? A) Glucose B) Acetyl-CoA C) Urea D) ATP directly
2. The removal of the nitrogen-containing group from an amino acid is called: A) Glycolysis B) Deamination C) Hydrolysis D) Oxidation
3. Which part of fat metabolism can enter glycolysis directly? A) Fatty acid B) Glycerol C) Cholesterol D) Acetyl-CoA

Answers: 1-B, 2-B, 3-B

3

Biological Molecules

The chemical building blocks of every living thing

PMDC Syllabus Unit 3 — Sub-topics: Biological Molecules, Water, Carbohydrates, Proteins, Lipids, RNA, Conjugated Molecules, Structure of DNA

Why water matters so much for life

Water isn't just a 'filler' liquid — its unique chemical properties make life possible. Because a water molecule is polar (slightly negative near oxygen, slightly positive near the hydrogens), water molecules stick to each other and to other polar substances.

Key Facts

Polarity	Lets water dissolve salts, sugars, and many biological molecules — making it an excellent solvent and reaction medium
Hydrolysis	Water molecules are used to break down large molecules (like starch into glucose) by splitting bonds with the addition of water
High specific heat	Water resists rapid temperature change, helping keep body/cell temperature stable
Cohesion & density	Water molecules stick together (cohesion) and are less dense as ice than as liquid, which is why ice floats

Carbohydrates, Proteins & Lipids — the 'big three'

Carbohydrates are built from sugar units: monosaccharides (like glucose) are single sugar units; oligosaccharides (like sucrose and lactose) are 2–10 units joined together; polysaccharides (like starch, cellulose, and glycogen) are long chains of hundreds of sugar units used for energy storage or structural support. Proteins are chains of amino acids folded into specific 3D shapes — the sequence of amino acids determines the protein's structure and function. Lipids include triglycerides (fats made of glycerol + 3 fatty acids joined by ester bonds) and phospholipids (which form cell membranes because they have both a water-loving 'head' and water-fearing 'tails').

RNA, conjugated molecules & the double helix of DNA

RNA (ribonucleic acid) is a single-stranded nucleic acid made of ribose sugar, phosphate, and nitrogenous bases (A, U, G, C) — it carries out protein synthesis instructions copied from DNA. Conjugated molecules are formed when a carbohydrate or lipid combines with another molecule — for example, glycoproteins (carbohydrate + protein) and glycolipids (carbohydrate + lipid), both important in cell recognition and membrane structure. DNA (deoxyribonucleic acid), as Watson and Crick proposed, is a double helix — two strands twisted around each other like a spiral staircase, held together by base pairing (A with T, G with C). A gene is simply a specific stretch of nucleotides within the DNA that codes for making one polypeptide (protein chain).

Key Facts

DNA shape	Double helix (Watson & Crick model)
Base pairing	Adenine–Thymine, Guanine–Cytosine
Gene	A sequence of nucleotides in DNA that codes for a polypeptide

MDCAT Tip

RNA has Uracil instead of Thymine, and ribose instead of deoxyribose — a favourite MDCAT 'spot the difference' question between DNA and RNA.

60-Second Revision

- Water's polarity, hydrolysis ability, high specific heat, and cohesion all support life processes
- Carbohydrates: mono-, oligo-, and polysaccharides; Proteins: chains of amino acids; Lipids: triglycerides & phospholipids
- RNA is single-stranded with uracil; DNA is a double helix with A-T and G-C base pairing
- A gene = a nucleotide sequence in DNA that codes for one polypeptide

Quick Check

1. Which base pairs with Adenine in DNA? A) Cytosine B) Guanine C) Thymine D) Uracil
2. Which of these is a polysaccharide? A) Glucose B) Sucrose C) Glycogen D) Lactose
3. A gene is best defined as: A) A whole chromosome B) A nucleotide sequence coding for a polypeptide C) A type of protein D) A type of lipid

Answers: 1-C, 2-C, 3-B

4 Cell Structure & Function

The basic unit of life, up close

PMDC Syllabus Unit 4 — Sub-topics: Cell Structure, Prokaryotic and Eukaryotic Cell, Cytoplasmic Organelles, Chromosomes

Animal vs plant cells

Both animal and plant cells are eukaryotic — they have a true nucleus and membrane-bound organelles. But plant cells have extra features animal cells lack: a rigid cellulose cell wall, a large central vacuole for storage and support, and chloroplasts for photosynthesis. Animal cells instead may have small vacuoles, centrioles, and no cell wall — giving them more flexible shapes.

Prokaryotic vs Eukaryotic cells

Prokaryotic cells (like bacteria) are simpler and smaller — they have no true nucleus (their DNA floats freely in the cytoplasm as a nucleoid) and lack membrane-bound organelles. Eukaryotic cells (animals, plants, fungi) are larger, more complex, and have a true nucleus enclosed by a nuclear envelope plus membrane-bound organelles such as mitochondria and the Golgi apparatus.

Key Facts

Prokaryotic	No nucleus, no membrane-bound organelles, smaller, simpler (e.g. bacteria)
Eukaryotic	True nucleus, membrane-bound organelles, larger, complex (e.g. humans, plants)

Key organelles and what they do

The nucleus is the cell's control centre — it houses DNA and directs all cell activities. The endoplasmic reticulum (ER) is a network of membranes: rough ER (studded with ribosomes) makes proteins, while smooth ER makes lipids and helps detoxify substances. The Golgi apparatus packages and modifies proteins and lipids before shipping them to their destination — like a cellular post office. Mitochondria are the 'powerhouses' of the cell, using respiration to generate ATP energy.

Key Facts

Nucleus	Control centre — houses DNA
Endoplasmic reticulum	Rough = protein synthesis; Smooth = lipid synthesis
Golgi apparatus	Packages & ships proteins/lipids
Mitochondria	Site of aerobic respiration — makes ATP

Chromosomes

A chromosome is a tightly coiled thread of DNA wrapped around proteins called histones, found in the nucleus. Chemically, a chromosome is made of DNA plus protein (chromatin). Its function is to carry the cell's genetic information in an organised, compact form so it can be accurately copied and passed on during cell division.

Common Trap

Don't confuse a chromosome with a gene — a chromosome is the whole coiled DNA-protein structure; a gene is just one small functional segment of that DNA.

60-Second Revision

- Plant cells have a cell wall, large vacuole & chloroplasts; animal cells don't
- Prokaryotic = no nucleus/no organelles; Eukaryotic = true nucleus + organelles
- Nucleus = control centre; ER = protein/lipid synthesis; Golgi = packaging; Mitochondria = ATP production
- Chromosomes = DNA + histone protein, carrying genetic information

Quick Check

1. Which structure is found in plant cells but NOT animal cells? A) Mitochondria B) Cell wall C) Nucleus D) Ribosomes
2. Which organelle is the 'powerhouse of the cell'? A) Golgi apparatus B) Nucleus C) Mitochondria D) Rough ER
3. A prokaryotic cell differs from a eukaryotic cell mainly because it lacks: A) Cytoplasm B) A true nucleus C) A cell membrane D) Ribosomes

Answers: 1-B, 2-C, 3-B

5

Coordination & Control

How your body senses the world and reacts to it

PMDC Syllabus Unit 5 — Sub-topics: Receptors, Neurons, Brain

Receptors — the body's sensors

A receptor is a specialised cell or structure that acts as a transducer — it converts one form of energy (light, sound, pressure, heat, or a chemical) into an electrical nerve impulse that the nervous system can understand and process.

Neurons — the wiring of the nervous system

A typical neuron has a cell body (containing the nucleus), dendrites (short branches that receive signals), and a long axon (often insulated by a fatty myelin sheath) that carries the signal onward to the next neuron or muscle. A nerve impulse is an electrical signal that travels rapidly along the neuron's membrane, allowing fast communication across the body.

Key Facts

Cell body	Contains nucleus; the neuron's 'control room'
Dendrites	Receive incoming signals
Axon + myelin sheath	Carries impulse away from the cell body; myelin speeds up transmission

Reflexes and the reflex arc

A reflex is a rapid, automatic response to a stimulus that happens without conscious thought — like pulling your hand away from a hot surface. Reflexes can be classified (e.g., simple vs conditioned). The pathway a reflex signal travels is called a reflex arc, made up of: a receptor (detects the stimulus) → sensory neuron (carries signal to spinal cord) → relay/connector neuron (processes it, often in the spinal cord — bypassing the brain for speed) → motor neuron (carries the response signal) → effector (muscle or gland that responds).

MDCAT Tip

Reflex arcs usually bypass the brain (going only through the spinal cord) — that's exactly why reflexes are so much faster than consciously-planned movements.

The brain — control headquarters

The brain has three main regions. The cerebrum (the largest part) handles conscious thought, memory, and voluntary movement. The cerebellum coordinates balance, posture, and fine muscle movements. The brain stem (including the mid-brain) controls automatic, life-sustaining functions like heart rate and breathing.

Key Facts

Cerebrum	Conscious thought, memory, voluntary movement
Cerebellum	Balance, coordination, fine motor control
Brain stem / mid-brain	Automatic functions — heart rate, breathing

60-Second Revision

- Receptors convert stimuli into nerve impulses (they're transducers)
- A neuron = cell body + dendrites + axon (often myelinated)
- Reflex arc: receptor → sensory neuron → relay neuron (spinal cord) → motor neuron → effector
- Cerebrum = thought & movement; Cerebellum = balance/coordination; Brain stem = automatic functions

Quick Check

1. A receptor's main job is to: A) Store memories B) Convert a stimulus into a nerve impulse C) Contract muscles D) Produce hormones
2. Which part of the neuron receives incoming signals? A) Axon B) Myelin sheath C) Dendrites D) Cell body only
3. Which brain region controls balance and coordination? A) Cerebrum B) Cerebellum C) Brain stem D) Spinal cord

Answers: 1-B, 2-C, 3-B

6

Enzymes

Biological catalysts that make life's chemistry fast enough to matter

PMDC Syllabus Unit 6 — Sub-topics: Enzymes, Mode of Enzyme Action, Factors that Affect the Rate of Enzyme Reactions, Inhibitors

What makes enzymes special?

Enzymes are biological catalysts — proteins that speed up chemical reactions without being used up themselves. They are highly specific (each enzyme usually acts on only one type of substrate), function best under particular conditions, and can be reused again and again.

How enzymes work — the lock-and-key idea

An enzyme has a special pocket called the active site, shaped to fit its specific substrate molecule (like a lock and key, or more precisely, an 'induced fit' where the site moulds slightly around the substrate). The substrate binds to the active site, forming an enzyme-substrate complex; the reaction occurs, and product(s) are released while the enzyme itself is unchanged and ready to work again.

Factors affecting enzyme activity

Enzyme activity depends heavily on conditions. As temperature rises, reaction rate increases (more kinetic energy = more collisions) — but too much heat denatures the enzyme (permanently changes its shape), destroying activity. Each enzyme also has an optimum pH; straying too far from it can also denature the enzyme. Increasing substrate or enzyme concentration increases the rate — up to a point where all active sites are saturated.

Key Facts

Temperature	Rate rises with temperature until the optimum, then crashes as the enzyme denatures
pH	Each enzyme has an optimum pH; extreme pH denatures it
Concentration	Rate rises with more substrate/enzyme until active sites become saturated

Common Trap

Don't say an enzyme is 'destroyed' by heat — it's denatured (its 3D shape unfolds), which is usually irreversible, but the enzyme molecule itself still physically exists, just non-functional.

Inhibitors — substances that slow enzymes down

An inhibitor is a molecule that reduces or blocks an enzyme's activity. Competitive inhibitors have a shape similar to the normal substrate, so they compete for the active site; increasing substrate concentration can outcompete them. Non-competitive inhibitors bind elsewhere on the enzyme, changing its shape so the active site no longer works properly — and adding more substrate does not reverse this effect.

60-Second Revision

- Enzymes are protein catalysts — specific, reusable, and unchanged by the reaction
- Enzyme action: substrate binds active site → enzyme-substrate complex → product released
- Rate increases with temperature/pH up to an optimum, then falls as the enzyme denatures

- Competitive inhibitors compete at the active site; non-competitive inhibitors change enzyme shape elsewhere

Quick Check

1. Enzymes are mostly made of: A) Carbohydrates B) Lipids C) Proteins D) Nucleic acids
2. Denaturation of an enzyme is caused by: A) Adding more substrate B) Extreme heat or pH C) Adding more enzyme D) Cooling slightly
3. A competitive inhibitor works by: A) Destroying the enzyme B) Binding at a site away from the active site C) Competing with the substrate for the active site D) Increasing enzyme concentration

Answers: 1-C, 2-B, 3-C

7 Evolution

How life's diversity came to be, over billions of years

PMDC Syllabus Unit 7 — Sub-topics: Concept of Evolution, Lamarckism, Darwinism

What is evolution?

Evolution is the idea that all life on Earth is related and has changed gradually over immense spans of time from earlier, simpler forms — explaining both the origin and the incredible diversity of living things we see today.

Lamarck's theory — inheritance of acquired characters

Jean-Baptiste Lamarck proposed that organisms change during their lifetime by using or disusing certain body parts, and that these acquired changes could be passed directly to their offspring. His classic example: a giraffe stretching its neck to reach high leaves would develop a slightly longer neck, and this longer neck would be inherited by its calves. This theory is now considered incorrect, because traits acquired during an individual's life (like a stretched neck or a bodybuilder's muscles) are not encoded in the DNA passed to offspring.

Darwin's theory — natural selection

Charles Darwin proposed natural selection: within any population there is natural variation between individuals; those with traits better suited to their environment are more likely to survive and reproduce ('survival of the fittest'), passing those favourable traits to the next generation. Over many generations, this gradually shifts the characteristics of the whole population.

Key Facts

Lamarckism	Acquired traits (gained during life) are inherited — now considered incorrect
Darwinism	Natural variation + survival advantage + reproduction of the fittest = gradual change over generations

MDCAT Tip

MDCAT often asks you to distinguish the two theories — Lamarck = 'use it and pass it on'; Darwin = 'nature selects who survives and reproduces'.

60-Second Revision

- Evolution = gradual change in life forms over long time spans, explaining diversity
- Lamarck: acquired characteristics (from use/disuse) are inherited — since disproven
- Darwin: natural selection acts on existing variation; the 'fittest' survive and reproduce
- Darwin's theory, not Lamarck's, is accepted by modern biology

Quick Check

1. Lamarck's theory is based on the idea of: A) Natural selection B) Inheritance of acquired characters C) Survival of the fittest D) Random mutation only
2. Darwin's theory of evolution is best summarised as: A) Use and disuse of organs B) Natural selection acting on variation C) Direct inheritance of learned skills D) Spontaneous generation
3. Which theory is currently accepted by mainstream biology? A) Lamarckism B) Darwinism C) Both equally D) Neither

Answers: 1-B, 2-B, 3-B

8 Reproduction

How the human body creates the next generation

PMDC Syllabus Unit 8 — Sub-topics: Human Reproductive System, Menstrual Cycle, Sexually Transmitted Diseases

Male and female reproductive systems

In males, the testes produce sperm and the hormone testosterone, which drives male secondary sexual characteristics and sperm production. Sperm travel through ducts, gaining nourishing fluids from glands (like the seminal vesicles and prostate) before being released. In females, the ovaries produce egg cells (ova) and the hormones oestrogen and progesterone, which control the reproductive cycle, egg release, and the uterus lining. Fertilisation normally occurs in the fallopian tube, and the developing embryo implants in the uterus.

The menstrual cycle

The menstrual cycle is a roughly monthly cycle that prepares the female body for a possible pregnancy, controlled mainly by four hormones: FSH and LH (from the pituitary gland) stimulate an egg follicle to mature and trigger ovulation (egg release); oestrogen (from the developing follicle) thickens the uterus lining; progesterone (from the corpus luteum, left behind after ovulation) maintains that lining. If no fertilisation occurs, hormone levels fall, the lining breaks down and is shed as menstruation, and the cycle begins again.

Key Facts

FSH & LH	Pituitary hormones — trigger follicle maturation & ovulation
Oestrogen	Thickens the uterus lining
Progesterone	Maintains the uterus lining (from corpus luteum)

MDCAT Tip

If pregnancy occurs, progesterone stays high to maintain the uterus lining — that's why no menstruation happens during pregnancy.

Sexually transmitted diseases

STDs are infections passed from person to person mainly through sexual contact. Common examples include gonorrhoea and syphilis (caused by bacteria) and HIV/AIDS (caused by a virus, covered in Unit 1). Common symptoms may include genital discharge, sores, pain, or — in the case of HIV — a slowly weakening immune system. Recognising the causative agents and main symptoms helps in understanding prevention and public health importance.

60-Second Revision

- Testes make sperm & testosterone; ovaries make eggs, oestrogen & progesterone
- Menstrual cycle: FSH/LH trigger ovulation; oestrogen builds the lining; progesterone maintains it
- No fertilisation → hormone levels drop → lining sheds → menstruation
- STDs (e.g. gonorrhoea, syphilis, HIV/AIDS) spread mainly through sexual contact, each with its own causative agent

Quick Check

1. Which hormone maintains the uterus lining after ovulation? A) FSH B) LH C) Progesterone D) Testosterone
2. Fertilisation normally takes place in the: A) Uterus B) Fallopian tube C) Ovary D) Vagina

3. AIDS is caused by which type of pathogen? A) Bacterium B) Fungus C) Virus D) Parasite

Answers: 1-C, 2-B, 3-C

9

Support & Movement

The framework and engines that let your body move

PMDC Syllabus Unit 9 — Sub-topics: Human Skeleton, Muscles, Skeletal Muscles, Muscle Contraction, Joints, Arthritis

Cartilage, muscle & bone

Bone is a hard, rigid connective tissue that provides support, protection, and attachment points for muscles — it's made of a matrix of collagen fibres hardened with calcium and phosphate minerals. Cartilage is a tougher-but-flexible connective tissue (with no mineral hardening), found where cushioning and flexibility are needed — such as between bones at joints, in the nose, and in the ear. Muscle is contractile tissue that shortens to produce movement.

Three types of muscle

Skeletal muscle (attached to bones) is striated (striped in appearance) and voluntary — you consciously control it. Cardiac muscle (found only in the heart) is also striated, but involuntary and can contract rhythmically on its own. Smooth muscle (found in organs like the gut and blood vessels) is non-striated and involuntary.

Key Facts

Skeletal muscle	Striated, voluntary — moves bones
Cardiac muscle	Striated, involuntary — only in the heart
Smooth muscle	Non-striated, involuntary — in organs/vessels

Skeletal muscle structure & contraction

A skeletal muscle is made of bundles of muscle fibres, each fibre packed with smaller units called myofibrils, which contain repeating units called sarcomeres — the basic contractile unit, built from overlapping thin (actin) and thick (myosin) protein filaments. During contraction, the myosin filaments 'pull' the actin filaments inward (the sliding filament mechanism), shortening the sarcomere and therefore the whole muscle, using ATP for energy.

Joints and arthritis

A joint is where two or more bones meet. Joints are classified by how much movement they allow: fixed/fibrous joints (immovable, like skull sutures), cartilaginous joints (slightly movable, like between vertebrae), and synovial joints (freely movable, like the knee or shoulder, cushioned by cartilage and lubricated by synovial fluid). Arthritis is inflammation of one or more joints, causing pain, stiffness, and swelling — it can result from wear-and-tear (osteoarthritis) or immune system attack on joint tissue (rheumatoid arthritis).

60-Second Revision

- Bone = rigid, mineralised support tissue; cartilage = flexible cushioning tissue
- Skeletal = striated/voluntary; Cardiac = striated/involuntary; Smooth = non-striated/involuntary
- Sarcomere = basic contractile unit; actin & myosin slide past each other to shorten muscle
- Joints range from fixed (fibrous) to freely movable (synovial); arthritis = joint inflammation

Quick Check

1. Which muscle type is both striated and involuntary? A) Skeletal B) Cardiac C) Smooth D) None
2. The basic contractile unit of a skeletal muscle fibre is called the: A) Neuron B) Sarcomere C) Nephron D) Alveolus

3. A freely movable joint, like the knee, is classified as: A) Fibrous B) Cartilaginous C) Synovial D) Fixed

Answers: 1-B, 2-B, 3-C

10

Inheritance

How traits pass from parents to offspring

PMDC Syllabus Unit 10 — Sub-topics: Mendel's Laws, Gene Linkage & Crossing Over, X-linked Recessive Inheritance

Mendel's laws of inheritance

Gregor Mendel, working with pea plants, discovered the basic rules of inheritance. The law of independent assortment states that genes for different traits (e.g., seed colour and seed shape) are inherited independently of one another, because different gene pairs separate independently during the formation of sex cells (gametes) — this explains why offspring can show new combinations of traits not seen in either parent.

Gene linkage and crossing over

Genes located close together on the same chromosome tend to be inherited together as a unit — this is called gene linkage, and it goes against independent assortment (which assumes genes are on different chromosomes or far apart). However, during the formation of gametes, homologous chromosomes can exchange segments in a process called crossing over, which shuffles linked genes and creates new combinations in the offspring — increasing genetic variation.

Key Facts

Gene linkage	Genes close together on the same chromosome are usually inherited as a group
Crossing over	Exchange of chromosome segments during gamete formation — breaks up linked genes, creating variation

Sex-linkage & X-linked recessive inheritance

Sex-linked traits are controlled by genes located on the sex chromosomes (X or Y) rather than on the other 'autosomal' chromosomes. Because the Y chromosome is much shorter than the X and carries far fewer genes, X-linked recessive traits (like haemophilia and colour blindness) show a distinctive inheritance pattern: males (who have only one X) show the trait whenever they inherit the recessive allele on their single X chromosome, while females (with two X chromosomes) usually need the recessive allele on BOTH X chromosomes to show the trait — making females more often 'carriers' who don't show it themselves.

MDCAT Tip

For X-linked recessive conditions like haemophilia, remember: an affected father cannot pass the condition to his son (he gives the son his Y chromosome), but he WILL pass the recessive allele to all his daughters (who become carriers, since he gives them his only X).

60-Second Revision

- Independent assortment: different gene pairs are inherited independently of each other
- Gene linkage: genes on the same chromosome tend to be inherited together
- Crossing over shuffles linked genes during gamete formation, increasing variation
- X-linked recessive traits (e.g. haemophilia) appear more often in males than females

Quick Check

1. Genes located close together on the same chromosome are said to show: A) Independent assortment B) Gene linkage C) Codominance D) Mutation
2. Crossing over occurs during: A) Mitosis only B) Formation of gametes C) Fertilisation D) Birth
3. Haemophilia shows which inheritance pattern? A) Autosomal dominant B) X-linked recessive C) Y-linked D) Mitochondrial

Answers: 1-B, 2-B, 3-B

11

Circulation

The transport network that keeps every cell supplied

PMDC Syllabus Unit 11 — Sub-topics: Human Heart, Cardiac Cycle, Blood Vessels, Lymphatic System

The human heart — a four-chambered pump

The heart has four chambers: two upper atria (receive blood) and two lower, more muscular ventricles (pump blood out). The right side pumps deoxygenated blood to the lungs; the left side (with a thicker, more muscular wall since it must pump blood around the entire body) pumps oxygenated blood to the rest of the body. One-way valves between chambers prevent blood from flowing backward.

The cardiac cycle — one heartbeat, step by step

Each heartbeat has two main phases: systole (contraction, pumping blood out) and diastole (relaxation, chambers filling with blood). During atrial systole, the atria contract, pushing blood into the ventricles; during ventricular systole, the ventricles contract, pushing blood out into the arteries; then both chambers relax together (diastole) as blood refills the atria, ready for the next cycle.

Key Facts

Systole	Contraction phase — chamber pumps blood out
Diastole	Relaxation phase — chamber fills with blood

Blood vessels — arteries, veins & capillaries

Arteries carry blood AWAY from the heart under high pressure, so they have thick, muscular, elastic walls. Veins carry blood TOWARD the heart under low pressure, so they have thinner walls and contain valves to prevent backflow. Capillaries are microscopic vessels with walls just one cell thick, allowing efficient exchange of oxygen, carbon dioxide, nutrients, and waste between blood and body tissues.

Common Trap

Don't assume all arteries carry oxygenated blood — the pulmonary artery carries deoxygenated blood to the lungs. It's about direction (away from the heart), not oxygen content!

The lymphatic system

The lymphatic system is a network of lymph vessels, lymph nodes, and lymphatic organs (like the spleen and tonsils) that collects excess tissue fluid (as lymph) and returns it to the bloodstream, while also filtering out pathogens and playing a key role in immunity via lymph nodes packed with white blood cells.

60-Second Revision

- Heart = 4 chambers; right side → lungs, left side → body
- Cardiac cycle: systole (contraction/pumping) + diastole (relaxation/filling)
- Arteries (thick, away from heart) vs veins (thinner, valves, toward heart) vs capillaries (thin, exchange)
- Lymphatic system: nodes, vessels & organs — returns fluid to blood and supports immunity

Quick Check

1. Which chamber of the heart has the most muscular wall? A) Right atrium B) Left atrium C) Left ventricle D) Right ventricle
2. Which vessels contain valves to prevent backflow? A) Arteries B) Veins C) Capillaries D) Aorta only
3. The exchange of gases and nutrients with tissues happens mainly at the: A) Arteries B) Veins C) Capillaries D) Heart

Answers: 1-C, 2-B, 3-C

12

Immunity

Your body's dedicated defense force

PMDC Syllabus Unit 12 — Sub-topics: Specific Defense Mechanism

Specific defense — a targeted immune response

Unlike general (non-specific) defenses such as skin or mucus, the specific defense mechanism targets a particular pathogen using specialised white blood cells called lymphocytes. B-lymphocytes produce antibodies — Y-shaped proteins that specifically recognise and bind to a matching antigen (a marker molecule on the pathogen's surface), marking it for destruction or neutralising it directly. T-lymphocytes act more directly, some destroying infected body cells, while 'helper' T-cells coordinate the overall immune response.

Key Facts

Antigen	A marker molecule (usually on a pathogen) that the immune system recognises as foreign
Antibody	A protein made by B-lymphocytes that specifically binds a matching antigen
B-lymphocytes	Produce antibodies
T-lymphocytes	Destroy infected cells directly / coordinate immune response

MDCAT Tip

MDCAT often tests the antigen-antibody 'lock and key' idea — each antibody fits only its matching antigen, just like an enzyme fits only its specific substrate.

Why specific immunity matters

Because specific immunity 'remembers' pathogens it has previously encountered (via memory cells), the body can respond faster and more strongly the second time it meets the same pathogen — this is the biological basis of immunity gained after an infection or a vaccination.

60-Second Revision

- Specific defense = targeted response by lymphocytes (B-cells and T-cells)
- B-lymphocytes make antibodies that match specific antigens
- T-lymphocytes destroy infected cells directly or coordinate the immune response
- Memory cells allow faster, stronger responses on repeat exposure to the same pathogen

Quick Check

1. Antibodies are produced by: A) T-lymphocytes B) B-lymphocytes C) Red blood cells D) Platelets
2. An antigen is best described as: A) A type of antibody B) A marker molecule recognised as foreign C) A white blood cell D) A type of vaccine
3. Faster immune response upon a second infection is due to: A) More red blood cells B) Memory cells C) Increased platelets D) Larger lymph nodes only

Answers: 1-B, 2-B, 3-B

13

Respiration

Getting oxygen in and carbon dioxide out

PMDC Syllabus Unit 13 — Sub-topics: Human Respiratory System

The pathway of air

Air travels: nose/mouth → pharynx → larynx → trachea (windpipe) → bronchi (one to each lung) → bronchioles (smaller branches) → alveoli (tiny air sacs where gas exchange happens). Each part along the way conditions the air — warming it, moistening it, and filtering out dust and pathogens using mucus and tiny hair-like cilia.

Gas exchange in the lungs

The alveoli are the site of gas exchange. Their walls are extremely thin (one cell thick) and surrounded by a dense network of capillaries, giving a huge surface area and short diffusion distance. Oxygen diffuses from the alveoli (high concentration) into the blood (low concentration), while carbon dioxide diffuses from the blood into the alveoli to be exhaled — both driven simply by diffusion along concentration gradients.

Key Facts

Alveoli features	Thin walls, moist surface, huge total surface area, rich capillary network
Oxygen	Diffuses: alveoli → blood
Carbon dioxide	Diffuses: blood → alveoli, then exhaled

Smoking and the respiratory system

Smoking damages the respiratory system in several ways: it paralyses and eventually destroys the cilia lining the airways (so dust, mucus, and pathogens are no longer swept out effectively), irritates and inflames the airway lining, and can permanently damage the delicate alveoli — reducing the surface area available for gas exchange. Over time, this contributes to chronic bronchitis, emphysema, and lung cancer.

Common Trap

Don't say smoking 'blocks' gas exchange directly — it destroys the structures (cilia, alveoli) that make efficient gas exchange possible in the first place.

60-Second Revision

- Air path: nose → pharynx → larynx → trachea → bronchi → bronchioles → alveoli
- Alveoli: thin, moist, huge surface area, richly supplied with capillaries — ideal for diffusion
- O2 diffuses into blood; CO2 diffuses out of blood, both by simple diffusion
- Smoking destroys cilia and damages alveoli, harming the lungs' ability to exchange gases

Quick Check

1. Gas exchange occurs at the: A) Trachea B) Bronchi C) Alveoli D) Larynx
2. Cilia in the airway mainly function to: A) Produce sound B) Sweep out mucus, dust & pathogens C) Absorb oxygen D) Produce antibodies

3. Long-term smoking primarily damages the lungs by: A) Increasing alveolar surface area B) Destroying cilia and damaging alveoli C) Strengthening the airway lining D) Improving gas diffusion

Answers: 1-C, 2-B, 3-B

14

Digestion

Breaking food down into nutrients your cells can use

PMDC Syllabus Unit 14 — Sub-topics: Human Digestive System

The digestive tract — a long tube with many stops

Food travels through: mouth (mechanical breakdown + salivary amylase begins starch digestion) → oesophagus (moves food to the stomach via muscular waves called peristalsis) → stomach (churns food and adds acid + protein-digesting enzymes) → small intestine (main site of digestion and absorption, aided by enzymes from the pancreas and bile from the liver/gallbladder) → large intestine (absorbs water, forms and stores faeces) → rectum and anus (elimination).

Associated glands and their roles

The liver produces bile, which doesn't contain enzymes but emulsifies fats (breaks large fat globules into smaller droplets), massively increasing the surface area available for enzymes to act on. The gallbladder stores and releases bile. The pancreas produces a cocktail of digestive enzymes (for carbohydrates, proteins, and fats) plus bicarbonate to neutralise stomach acid as food enters the small intestine.

Key Facts

Mouth	Mechanical digestion + amylase (starch → sugars)
Stomach	Acid + pepsin (protein digestion) + churning
Liver / gallbladder	Bile — emulsifies fats (no enzymes)
Pancreas	Enzymes for carbs, proteins & fats + bicarbonate (neutralises acid)
Small intestine	Main site of digestion & nutrient absorption

MDCAT Tip

Bile is NOT an enzyme — it's often confused with one. Bile physically emulsifies fat; enzymes chemically break bonds.

60-Second Revision

- Digestive path: mouth → oesophagus → stomach → small intestine → large intestine → rectum/anus
- Salivary amylase starts starch digestion in the mouth; stomach acid + pepsin digest protein
- Bile (from liver, stored in gallbladder) emulsifies fat — it is not an enzyme
- Pancreas supplies digestive enzymes + bicarbonate; small intestine is the main site of absorption

Quick Check

1. Bile is produced by the: A) Pancreas B) Liver C) Stomach D) Small intestine
2. The main site of nutrient absorption is the: A) Stomach B) Large intestine C) Small intestine D) Oesophagus
3. Bile's main function is to: A) Digest proteins B) Neutralise acid C) Emulsify fats D) Absorb water

Answers: 1-B, 2-C, 3-C

15

Homeostasis

Keeping the body's internal environment stable

PMDC Syllabus Unit 15 — Sub-topics: Urinary System & Kidney, Thermoregulation, Excretion

The urinary system and kidney structure

The urinary system consists of two kidneys (which filter blood and produce urine), two ureters (carry urine to the bladder), a urinary bladder (stores urine), and a urethra (carries urine out of the body). Each kidney contains millions of tiny filtering units called nephrons.

How the kidney makes urine — three key steps

Glomerular filtration: blood pressure forces water, glucose, salts, urea, and other small molecules out of the glomerulus (a tiny capillary knot) into the nephron — but large molecules like proteins and blood cells stay in the blood. Selective reabsorption: as the filtrate flows along the nephron tubule, useful substances (glucose, most water, needed salts) are reabsorbed back into the blood. Tubular secretion: some additional waste substances and excess ions are actively added into the tubule from the blood, fine-tuning the urine's final composition.

Key Facts

Glomerular filtration	Forces small molecules out of blood into the nephron
Selective reabsorption	Useful substances (glucose, water) return to blood
Tubular secretion	Extra wastes/ions added into the filtrate

Excretion AND osmoregulation — a dual job

The kidney does two jobs at once: excretion (removing metabolic waste, especially nitrogenous waste like urea) and osmoregulation (controlling the water and salt balance/concentration of the blood). The two major capillary networks — glomerular capillaries (high pressure, drive filtration) and peritubular capillaries (surround the tubule, reabsorb useful substances) — work together to achieve both jobs.

When things go wrong

Kidney stones form when minerals and salts (like calcium oxalate) crystallise and clump together in the urinary tract, often due to dehydration or high mineral concentration; treatment ranges from increased fluid intake to sound-wave therapy (breaking stones up) or surgery for larger stones. Kidney failure (the kidneys losing their filtering ability) can result from long-term high blood pressure, diabetes, severe infections, or blockages, and may require dialysis or a transplant.

Thermoregulation & excretion of nitrogenous waste

Thermoregulation is the process of maintaining a stable internal body temperature despite a changing external environment — essential because enzymes (and therefore all metabolism) only work efficiently within a narrow temperature range. Nitrogenous waste comes mainly from the breakdown of excess amino acids (protein metabolism); in humans this waste is converted to urea (a less toxic form of nitrogen waste than ammonia) and excreted via the kidneys.

60-Second Revision

- Kidney: filters blood, forms urine via filtration → reabsorption → secretion
- Kidneys perform BOTH excretion (removing waste) AND osmoregulation (water/salt balance)
- Glomerular capillaries drive filtration; peritubular capillaries handle reabsorption

- Thermoregulation keeps body temperature stable so enzymes/metabolism function properly

Quick Check

1. Glomerular filtration mainly removes: A) Large proteins only B) Small molecules like water, glucose, urea C) Red blood cells D) Nothing, it only adds substances
2. The kidney's dual role is excretion and: A) Digestion B) Osmoregulation C) Respiration D) Circulation
3. Nitrogenous waste from protein breakdown is excreted mainly as: A) Ammonia B) Uric acid C) Urea D) Carbon dioxide

Answers: 1-B, 2-B, 3-C

16

Biotechnology

Using living systems to solve health problems

PMDC Syllabus Unit 16 — Sub-topics: Biotechnology and Health Care

Vaccines — training the immune system

Biotechnologists use genetic engineering to produce vaccines that safely expose the immune system to a harmless version or piece of a pathogen (like a single protein), triggering the production of antibodies and memory cells — without causing the actual disease. This means the body is ready to respond quickly and strongly if it ever meets the real pathogen.

Diagnosing disease with biotechnology

DNA/RNA probes are short, labelled strands of nucleic acid designed to bind specifically to a matching sequence from a pathogen's genetic material — allowing doctors to detect infections at the genetic level, quickly and accurately. Monoclonal antibodies are identical, lab-produced antibodies engineered to bind one specific antigen; they're used in diagnostic tests (like pregnancy tests) and to detect specific diseases by targeting unique marker molecules.

Key Facts

DNA/RNA probes	Detect specific genetic sequences from pathogens
Monoclonal antibodies	Identical antibodies targeting one specific antigen — used in diagnosis

Treatment products from biotechnology

Biotechnology also produces treatment products such as genetically engineered human insulin (for diabetes), clotting factors (for haemophilia), and growth hormone — all made by inserting the relevant human gene into bacteria or other host cells, which then mass-produce the protein in a lab setting, safely and in large quantities.

MDCAT Tip

Remember the three biotech health contributions as a set: (1) Vaccines — prevention, (2) DNA/RNA probes & monoclonal antibodies — diagnosis, (3) Engineered proteins like insulin — treatment.

60-Second Revision

- Biotechnology helps produce vaccines that train immunity without causing disease
- DNA/RNA probes detect specific genetic sequences — useful for diagnosing infections
- Monoclonal antibodies are identical, lab-made antibodies targeting one specific antigen
- Engineered organisms (e.g. bacteria) mass-produce treatment proteins like human insulin

Quick Check

1. Monoclonal antibodies are best described as: A) A type of vaccine B) Identical antibodies targeting one antigen C) A type of DNA probe D) A type of nitrogenous waste
2. DNA/RNA probes are mainly used for: A) Treating diabetes B) Detecting specific genetic sequences C) Producing insulin D) Forming vaccines only
3. Human insulin used for diabetes treatment is produced by: A) Extracting it from pigs only B) Genetically engineered bacteria/host cells C) Chemical synthesis from sugar D) Boiling animal blood

Answers: 1-B, 2-B, 3-B

All 16 Units Complete!

You've now revised every Biology sub-topic that PMDC lists across all 16 units — the largest and highest-weightage section of the MDCAT (45%, 81 MCQs). Go back through each Key Facts box, retake every Quick Check, and keep an eye on the Common Traps — they are the exact spots where MDCAT candidates lose easy marks. Best of luck on your MDCAT journey!

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MDCAT TEST PREPARATION

CHEMISTRY

Revision Guide — Strictly Mapped to the Official PMDC MDCAT 2025 Syllabus (Chemistry Section)

Every topic taken directly from PMDC's official MDCAT Chemistry curriculum

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Contents

Built unit-by-unit from PMDC's MDCAT 2025 Chemistry syllabus (Section 2)

How to use this book: Read each concept in plain language, lock in the key-facts box, dodge the trap box, note the MDCAT tip, and test yourself with the Quick Check MCQs at the end of every unit. This guide covers only topics listed in PMDC's official MDCAT 2025 Chemistry curriculum — nothing extra, nothing skipped.

1 Fundamental Concepts of Chemistry

Counting atoms and molecules using the mole

PMDC Syllabus Unit 1 — Sub-topics: Moles & Avogadro's Number, Limiting & Excess Reactants, Yield

The mole — a chemist's 'dozen'

Atoms and molecules are far too small and numerous to count one by one, so chemists use a convenient counting unit called the mole. One mole of any substance always contains the same number of particles — Avogadro's number, 6.022×10^{23}. A balanced chemical equation gives mole ratios between reactants and products, which act as conversion factors letting you calculate moles, number of particles, mass, or gas volume (at STP) of any substance in the reaction.

Key Facts

1 mole	6.022×10^{23} particles (Avogadro's number)
1 mole of gas at STP	Occupies 22.4 dm^3 (22.4 L)
Mole ratio	Comes directly from the coefficients of a balanced equation

Limiting and excess reactants

In most reactions, reactants aren't mixed in exact matching amounts. The limiting reagent is the reactant that gets completely used up first — it determines the maximum amount of product that can form and 'limits' the reaction. Any reactant left over once the limiting reagent runs out is called the excess reactant.

MDCAT Tip

To identify the limiting reagent, calculate how much product each reactant COULD make on its own — whichever gives the SMALLER amount of product is the limiting reagent.

Theoretical yield vs actual yield

Theoretical yield is the maximum amount of product calculated from the balanced equation, assuming the reaction goes perfectly. Actual yield is what you really collect in the lab — always a bit less, due to side reactions, incomplete reactions, or losses during the process. Percentage yield compares the two: % yield = (actual yield ÷ theoretical yield) × 100.

Key Facts

Percentage yield formula	% Yield = (Actual Yield ÷ Theoretical Yield) × 100

60-Second Revision

- 1 mole = 6.022×10^{23} particles; 1 mole of gas at STP = 22.4 dm^3
- The limiting reagent runs out first and determines maximum product formed
- Excess reactant is left over once the limiting reagent is used up
- % Yield = (Actual ÷ Theoretical) × 100 — actual yield is always ≤ theoretical yield

Quick Check

1. Avogadro's number is approximately: A) 6.022×10^{22} B) 6.022×10^{23} C) 3.14×10^{23} D) 22.4×10^{23}
2. The reactant that is completely used up first in a reaction is called the: A) Excess reactant B) Catalyst C) Limiting reagent D) Product

3. If theoretical yield is 50 g and actual yield is 40 g, the percentage yield is: A) 50% B) 80% C) 40% D) 100%

Answers: 1-B, 2-C, 3-B

2 Atomic Structure

The tiny world inside every atom

PMDC Syllabus Unit 2 — Sub-topics: Discovery of Proton, Planck's Quantum Theory, Quantum Numbers, Shapes of Orbitals, Spectrum of Hydrogen, Electronic Configuration

Discovery of the proton & the quantum idea

The proton, a positively charged particle inside the atom's nucleus, was identified through experiments with 'positive rays' in discharge tubes. Around the same time, Max Planck proposed that energy is not released continuously but in small, fixed packets called quanta — the energy of a single packet of radiation (a photon) is given by E = hf, where h is Planck's constant and f is the frequency.

Quantum numbers & atomic orbitals

Instead of orbits (fixed paths), electrons occupy orbitals — three-dimensional regions of space around the nucleus where an electron is most likely to be found. Each orbital is described by a set of quantum numbers: the principal quantum number (n) shows the main energy level (shell); within each shell there are sub-levels (s, p, d, f), each made of a specific number of orbitals.

Key Facts

s sub-level	1 orbital — spherical shape
p sub-level	3 orbitals — dumbbell shape
d sub-level	5 orbitals — more complex, cloverleaf-like shapes

The hydrogen spectrum & electronic configuration

When hydrogen atoms are energised, their electrons jump to higher energy levels and then fall back down, releasing energy as light of specific wavelengths — producing the hydrogen line spectrum, direct evidence that electrons exist only at fixed, quantised energy levels (not just anywhere). To write an atom's electronic configuration, we fill orbitals using three rules: the Aufbau principle (fill lowest-energy orbitals first), the Pauli Exclusion Principle (each orbital holds a maximum of 2 electrons, with opposite spins), and Hund's Rule (electrons fill separate orbitals of equal energy singly before pairing up).

MDCAT Tip

Remember the filling order with the diagonal rule: 1s, 2s, 2p, 3s, 3p, 4s, 3d, 4p... — MDCAT frequently tests why 4s fills before 3d.

60-Second Revision

- Planck: energy is released in quanta; E = hf
- Electrons occupy orbitals (regions of probability), not fixed orbits
- s = 1 orbital (spherical), p = 3 orbitals (dumbbell), d = 5 orbitals
- Aufbau, Pauli Exclusion & Hund's Rule together determine electronic configuration

Quick Check

1. The energy of a photon is given by: A) $E = mc^2$ B) $E = hf$ C) $E = mgh$ D) $E = \frac{1}{2}mv^2$
2. How many orbitals are present in a p sub-level? A) 1 B) 3 C) 5 D) 7
3. Which rule states that each orbital can hold a maximum of 2 electrons with opposite spins? A) Aufbau principle B) Hund's rule C) Pauli exclusion principle D) Le Chatelier's principle

Answers: 1-B, 2-B, 3-C

3 Gases

The most 'free' state of matter — and the laws that describe it

PMDC Syllabus Unit 3 — Sub-topics: Kinetic Molecular Theory, STP, Boyle's Law, Charles's Law, Absolute Zero, Ideal Gas Equation, Real vs Ideal Gases

Kinetic Molecular Theory — gases in constant motion

According to Kinetic Molecular Theory, gas particles are in continuous, random, rapid motion, are widely spaced apart (with negligible volume compared to the container), and have no attractive forces between them in an ideal gas. Collisions between particles (and with container walls) are perfectly elastic — no energy is lost overall.

Boyle's Law & Charles's Law

Boyle's Law states that at constant temperature, the volume of a fixed amount of gas is inversely proportional to its pressure — squeeze a gas and its volume shrinks. Charles's Law states that at constant pressure, the volume of a fixed amount of gas is directly proportional to its absolute (Kelvin) temperature — heat a gas and it expands.

Key Facts

Boyle's Law	$P_1V_1 = P_2V_2$ (constant T)
Charles's Law	$V_1/T_1 = V_2/T_2$ (constant P)
Absolute zero	−273°C (0 K) — the temperature at which gas volume/pressure would theoretically become zero

The Ideal Gas Equation

Combining Boyle's Law, Charles's Law, and Avogadro's Law (equal volumes of gases at the same temperature and pressure contain equal numbers of moles) gives the ideal gas equation: PV = nRT, where R is the universal gas constant. Standard Temperature and Pressure (STP) is defined as 0°C (273 K) and 1 atmosphere pressure.

Key Facts

Ideal gas equation	PV = nRT
STP	0°C (273 K) and 1 atm

Real gases vs the ideal gas model

An ideal gas is a theoretical model that assumes zero particle volume and zero intermolecular forces. Real gases deviate from this ideal behaviour, especially at high pressure (particles are squeezed close enough that their own volume matters) and low temperature (particles slow down enough for intermolecular attractions to become significant).

Common Trap

Don't assume real gases always behave ideally — MDCAT often tests that deviation from ideal behaviour is worst at HIGH pressure and LOW temperature.

60-Second Revision

- Kinetic theory: gas particles move randomly, have negligible volume, no attractive forces (ideal gas)
- Boyle's Law: $P_1V_1 = P_2V_2$ (constant T); Charles's Law: $V_1/T_1 = V_2/T_2$ (constant P)
- Ideal gas equation: PV = nRT; STP = 0°C (273 K), 1 atm

- Real gases deviate most from ideal behaviour at high pressure and low temperature

Quick Check

1. At constant temperature, if pressure on a gas doubles, its volume: A) Doubles B) Halves C) Stays the same D) Quadruples
2. Absolute zero is equal to: A) 0°C B) 100°C C) −273°C D) 273°C
3. Real gases deviate most from ideal gas behaviour at: A) Low pressure, high temperature B) High pressure, low temperature C) Any pressure and temperature equally D) STP only

Answers: 1-B, 2-C, 3-B

4 Liquids

The 'in-between' state — free to move, but sticking together

PMDC Syllabus Unit 4 — Sub-topics: Properties of Liquids (Kinetic Molecular Theory), Evaporation, Boiling Point & Vapor Pressure, Hydrogen Bonding, Anomalous Behaviour of Water

Why liquids behave the way they do

In liquids, particles are close together (much closer than in gases) but still able to slide past one another, which is why liquids can flow and take the shape of their container, yet resist compression. Liquids show diffusion (though much slower than gases, since particles are closer together and collide more often) and have measurable intermolecular forces holding particles together.

Evaporation, vapor pressure & boiling point

Evaporation is the escape of higher-energy particles from a liquid's surface into the gas phase, even below the boiling point. The vapour escaping above a liquid exerts a vapour pressure; as temperature rises, more particles have enough energy to escape, so vapour pressure increases. A liquid boils when its vapour pressure becomes equal to the surrounding atmospheric pressure — that temperature is its boiling point.

Key Facts

Evaporation	Surface particles escape into vapour, even below boiling point
Boiling point	Temperature at which vapour pressure = atmospheric pressure

Hydrogen bonding & water's strange behaviour

A hydrogen bond is a relatively strong intermolecular attraction that forms when a hydrogen atom bonded to a highly electronegative atom (like O, N, or F) is attracted to a lone pair of electrons on a neighbouring electronegative atom — seen clearly in H_2O, NH_3, and HF. Hydrogen bonding gives water unusually high boiling point, high specific heat, and — most famously — an anomalous density behaviour: water is actually densest at 4°C, not at its freezing point, which is why ice floats on liquid water instead of sinking.

MDCAT Tip

The fact that ice floats (is less dense than liquid water) is a classic MDCAT question — it happens because hydrogen bonds arrange water molecules into a more open, spaced-out lattice structure when frozen.

60-Second Revision

- Liquid particles are close together but can flow past each other
- Evaporation happens below boiling point; boiling point = vapour pressure equals atmospheric pressure
- Hydrogen bonding occurs in H_2O, NH_3, HF — strong attraction via H bonded to O/N/F
- Water is densest at 4°C, not at 0°C — this is why ice floats

Quick Check

1. A liquid boils when its vapour pressure: A) Becomes zero B) Equals atmospheric pressure C) Becomes negative D) Is always constant
2. Hydrogen bonding is strongest between hydrogen and which type of atoms? A) Carbon B) Highly electronegative atoms (O, N, F) C) Noble gases D) Metals
3. Water shows maximum density at: A) 0°C B) 4°C C) 100°C D) −4°C

Answers: 1-B, 2-B, 3-B

5

Solids

Matter locked into fixed, orderly positions

PMDC Syllabus Unit 5 — Sub-topics: Crystalline Solids, Factors Affecting Shape of Ionic Crystals, Ionic vs Molecular Crystals, Crystal Lattice, Lattice Energy

Crystalline solids — order down to the atomic level

A crystalline solid has particles (atoms, ions, or molecules) arranged in a highly ordered, repeating three-dimensional pattern, giving it a definite geometric shape and a sharp, fixed melting point — unlike amorphous solids (like glass), which lack this long-range order and soften gradually over a range of temperatures.

The crystal lattice & factors shaping ionic crystals

A crystal lattice is the repeating three-dimensional geometric arrangement of particles throughout a crystalline solid. For ionic crystals specifically, the resulting shape depends on factors such as the relative sizes of the cation and anion, the ratio of cations to anions in the formula, and the requirement that opposite charges pack together while like charges stay apart (to keep the structure electrically balanced and stable).

Ionic vs molecular crystals

Ionic crystals are held together by strong electrostatic attraction between oppositely charged ions throughout the lattice — giving them high melting points, hardness, and brittleness (e.g., sodium chloride). Molecular crystals are held together only by weaker intermolecular forces (like hydrogen bonds or van der Waals forces) between whole molecules — giving them much lower melting points and softness (e.g., ice, solid iodine).

Key Facts

Ionic crystal	Ions held by strong electrostatic forces — high melting point, hard, brittle
Molecular crystal	Molecules held by weak intermolecular forces — low melting point, soft

Lattice energy

Lattice energy is the energy released when gaseous ions come together to form one mole of a solid ionic crystal lattice (or, equivalently, the energy required to break that lattice apart into separate gaseous ions). A higher lattice energy means a stronger, more stable ionic structure — generally lattice energy increases as ionic charge increases and as ionic size (radius) decreases.

60-Second Revision

- Crystalline solids have long-range, ordered particle arrangement and a sharp melting point
- Crystal lattice shape (for ionic crystals) depends on ion size ratio, charge ratio, and charge balance
- Ionic crystals: strong electrostatic forces, high melting point; Molecular crystals: weak forces, low melting point
- Lattice energy increases with higher ionic charge and smaller ionic radius

Quick Check

1. A crystalline solid, unlike an amorphous solid, has: A) No definite shape B) A sharp, fixed melting point C) No particles D) Only covalent bonds

2. Ionic crystals are generally: A) Soft with low melting points B) Hard with high melting points C) Gases at room temperature D) Held by weak forces only
3. Lattice energy generally increases when ionic radius: A) Increases B) Decreases C) Has no effect D) Becomes zero

Answers: 1-B, 2-B, 3-B

6 Chemical Equilibrium

When a reaction seems to 'stop' — but keeps going both ways

PMDC Syllabus Unit 6 — Sub-topics: Chemical Equilibrium, Le Chatelier's Principle, Solubility Products, Common Ion Effect, Buffer Solutions, Haber's Process

What is chemical equilibrium?

Many reactions are reversible — they can proceed forward (reactants → products) and backward (products → reactants) at the same time. Chemical equilibrium is reached when the forward and reverse reaction rates become equal, so the concentrations of reactants and products stop changing (though both reactions are still actively happening — it's a dynamic, not a frozen, state).

Le Chatelier's Principle — how equilibrium responds to change

Le Chatelier's Principle states that if a system at equilibrium is disturbed (by a change in concentration, pressure, or temperature), the equilibrium shifts in the direction that partly counteracts that disturbance, reaching a new equilibrium position. Adding a catalyst, however, speeds up BOTH the forward and reverse reactions equally, helping equilibrium get reached faster — but without shifting its position.

Key Facts

Increase reactant concentration	Equilibrium shifts forward (toward products)
Increase pressure	Equilibrium shifts toward the side with fewer gas moles
Increase temperature	Equilibrium shifts in the endothermic direction
Add a catalyst	Reaches equilibrium faster — position does NOT shift

Common Trap

A catalyst never shifts the position of equilibrium — it only helps the system reach equilibrium more quickly by speeding up both directions equally.

Solubility product, common ion effect & buffers

The solubility product (Ksp) is the equilibrium constant for the dissolving of a sparingly soluble ionic compound — it tells us how far a compound will dissolve before the solution becomes saturated. The common ion effect describes how adding a soluble compound that shares an ion with a sparingly soluble salt reduces that salt's solubility, by shifting its dissolving equilibrium backward (Le Chatelier's principle at work). A buffer solution resists changes in pH when small amounts of acid or base are added, typically made from a weak acid plus its conjugate base (acidic buffer) or a weak base plus its conjugate acid (basic buffer).

Haber's Process — equilibrium in industry

The Haber process manufactures ammonia (NH_3) from nitrogen and hydrogen gas: $N_2 + 3H_2 \rightleftharpoons 2NH_3$. Since this reaction is reversible and exothermic, industrial conditions (moderately high pressure, moderate temperature, and an iron catalyst) are carefully chosen as a practical compromise between maximising yield (favoured by Le Chatelier's principle at lower temperature and higher pressure) and achieving a fast enough reaction rate.

60-Second Revision

- Equilibrium: forward rate = reverse rate; concentrations stay constant (dynamic, not static)
- Le Chatelier: system shifts to counteract a disturbance (concentration, pressure, temperature)

- A catalyst speeds up both directions equally — it never shifts equilibrium position
- Haber's process ($N_2 + 3H_2 \rightleftharpoons 2NH_3$) balances yield vs. rate using pressure, temperature & a catalyst

Quick Check

1. At equilibrium: A) The reaction has completely stopped B) Forward and reverse rates are equal C) Only the forward reaction occurs D) Concentrations are always zero
2. Adding a catalyst to a system at equilibrium: A) Shifts equilibrium toward products B) Shifts equilibrium toward reactants C) Does not shift equilibrium position D) Stops the reverse reaction
3. In the Haber process, ammonia is made from: A) Nitrogen and oxygen B) Nitrogen and hydrogen C) Hydrogen and oxygen D) Carbon and hydrogen

Answers: 1-B, 2-C, 3-B

7

Reaction Kinetics

How fast — and why — reactions happen

PMDC Syllabus Unit 7 — Sub-topics: Chemical Kinetics, Factors Affecting Rate, Order of Reaction, Activation Energy, Rate Constant

Rate of reaction — how quickly things change

Chemical kinetics is the study of reaction rates and the factors that affect them. The rate of reaction is how fast reactant concentration decreases (or product concentration increases) per unit time. A rate equation (rate law) expresses this rate mathematically in terms of reactant concentrations, each raised to a power called its order.

Factors affecting rate of reaction

Reaction rate increases with higher concentration (more particles = more frequent collisions), higher temperature (particles move faster and collide with more energy), greater surface area of solid reactants (more contact area for reaction), and the presence of a catalyst (which provides an alternative reaction pathway with lower activation energy).

Activation energy & the activated complex

Activation energy is the minimum energy that colliding particles must have for a reaction to actually occur — think of it as an 'energy hill' that reactants must climb over. At the peak of that hill sits a temporary, high-energy, unstable arrangement of atoms called the activated complex (or transition state), which then breaks down into products. A lower activation energy means more particles have enough energy to react at any given temperature, so the reaction proceeds faster.

Key Facts

Activation energy (Ea)	Minimum energy needed for a successful collision/reaction
Activated complex	Unstable, high-energy transition arrangement at the peak of the energy barrier
Catalyst's role	Lowers activation energy, providing an alternative pathway — speeding up the rate

The rate constant

In a rate equation such as rate = k[A]^n, k is the rate constant — a value specific to a given reaction at a given temperature, which links concentration to rate. A larger rate constant means a faster reaction at that temperature; the rate constant itself increases with temperature (since more particles then have energy above the activation energy).

60-Second Revision

- Rate = how fast reactant concentration falls / product concentration rises, per unit time
- Rate increases with: concentration, temperature, surface area, and catalysts
- Activation energy = energy barrier for reaction; activated complex = the unstable peak arrangement
- Rate constant (k) links concentration to rate — and increases with temperature

Quick Check

1. Increasing temperature increases reaction rate mainly because: A) Particles become heavier B) Particles collide more often and with more energy C) Particles stop moving D) Volume decreases
2. A catalyst speeds up a reaction by: A) Increasing activation energy B) Decreasing activation energy C) Increasing temperature only D) Removing reactants

3. The activated complex is best described as: A) The final stable product B) An unstable, high-energy transition arrangement C) A catalyst D) The reactant itself

Answers: 1-B, 2-B, 3-B

8 Thermochemistry & Energetics

Tracking the energy that flows into and out of reactions

PMDC Syllabus Unit 8 — Sub-topics: Thermodynamics, Exothermic & Endothermic Reactions, System/Boundary Terms, Internal Energy, First Law of Thermodynamics, Hess's Law, Enthalpy

Exothermic vs endothermic reactions

Thermodynamics is the study of heat and energy changes. In an exothermic reaction, energy is released to the surroundings (often as heat), so the surroundings get warmer — like combustion. In an endothermic reaction, energy is absorbed from the surroundings, so the surroundings get cooler — like the dissolving of certain salts in water.

System, surroundings & key terms

The system is the specific part of the universe being studied (e.g., the reacting chemicals); the surroundings is everything else. A boundary separates the two. Internal energy is the total energy (kinetic + potential) stored within a system. Heat capacity is the amount of heat needed to raise a substance's temperature by one degree.

Key Facts

System	The part being studied (e.g., the reaction mixture)
Surroundings	Everything outside the system
Internal energy (U)	Total stored energy of the system

The First Law of Thermodynamics

The First Law is simply the conservation of energy applied to heat and work: the change in internal energy of a system equals the heat added to the system minus the work done BY the system (or plus the work done ON the system, depending on the sign convention used). Energy cannot be created or destroyed — it can only be transferred as heat or work, or converted between the two.

Key Facts

First Law	$\Delta U = Q - W$ (energy is conserved — never created or destroyed)

Hess's Law & enthalpy

Enthalpy (H) is the heat content of a system at constant pressure; the enthalpy change (ΔH) of a reaction is negative for exothermic reactions and positive for endothermic reactions. Hess's Law states that the total enthalpy change for a reaction is the same regardless of the route taken from reactants to products — because enthalpy is a state function (it depends only on the initial and final states, not the path). This lets chemists calculate enthalpy changes for reactions that are difficult to measure directly, by adding up enthalpy changes of simpler, known steps that lead to the same overall reaction.

MDCAT Tip

Hess's Law questions are just 'energy cycle' addition problems: rearrange and add/subtract the given equations (and their ΔH values) so they combine to give the target equation.

60-Second Revision

- Exothermic reactions release energy (ΔH negative); endothermic reactions absorb energy (ΔH positive)
- First Law of Thermodynamics: energy is conserved — $\Delta U = Q - W$

- Enthalpy is a state function — depends only on initial & final states, not the path taken
- Hess's Law: total ΔH for a reaction is the same via any route — allows energy cycle calculations

Quick Check

1. An exothermic reaction: A) Absorbs heat from surroundings B) Releases heat to surroundings C) Has no energy change D) Only occurs in solids
2. Hess's Law is based on the idea that enthalpy is a: A) Path function B) State function C) Kinetic property D) Type of catalyst
3. The First Law of Thermodynamics is essentially a statement of: A) Conservation of mass B) Conservation of energy C) Conservation of momentum D) Conservation of charge

Answers: 1-B, 2-B, 3-B

9 Electrochemistry

Chemistry that produces (or uses) electricity

PMDC Syllabus Unit 9 — Sub-topics: Redox Reactions, Oxidation & Reduction, Balancing Redox Equations, Standard Hydrogen Electrode

Redox reactions — electrons on the move

A redox (reduction-oxidation) reaction always involves both oxidation and reduction happening together — one substance cannot be oxidised unless another is simultaneously reduced. Oxidation is a loss of electrons (or an increase in oxidation number); reduction is a gain of electrons (or a decrease in oxidation number).

Key Facts

Oxidation	Loss of electrons; oxidation number increases
Reduction	Gain of electrons; oxidation number decreases
Mnemonic	OIL RIG — Oxidation Is Loss, Reduction Is Gain (of electrons)

Balancing redox equations using oxidation numbers

To balance a redox equation using the oxidation-number-change method: identify which atoms change oxidation number, calculate the total increase (oxidation) and total decrease (reduction), then use coefficients so the total electrons lost equal the total electrons gained — keeping the equation both mass-balanced and charge-balanced.

Standard Hydrogen Electrode & electrode potential

An electrode potential measures a half-cell's tendency to gain or lose electrons compared to a reference. The cathode is the electrode where reduction occurs; the anode is where oxidation occurs. Since electrode potentials can't be measured in isolation, the Standard Hydrogen Electrode (SHE) is used as the universal reference point, arbitrarily assigned an electrode potential of exactly 0.00 volts under standard conditions — every other electrode's standard potential is measured relative to it.

MDCAT Tip

Remember 'Reduction happens at the Cathode' — both start with a vowel-adjacent pattern (Red Cat), a handy memory trick that MDCAT candidates find useful.

60-Second Revision

- Redox reactions always pair oxidation (electron loss) with reduction (electron gain)
- OIL RIG: Oxidation Is Loss, Reduction Is Gain of electrons
- Redox equations are balanced by equalising total electrons lost and gained
- SHE (Standard Hydrogen Electrode) = 0.00 V reference; reduction occurs at the cathode

Quick Check

1. Oxidation is defined as: A) Gain of electrons B) Loss of electrons C) Gain of protons D) Loss of neutrons
2. The Standard Hydrogen Electrode has a defined electrode potential of: A) 1.00 V B) −1.00 V C) 0.00 V D) 100 V
3. Reduction occurs at which electrode? A) Anode B) Cathode C) Both equally D) Neither

Answers: 1-B, 2-C, 3-B

10

Chemical Bonding

Why atoms stick together — and what shapes they make

PMDC Syllabus Unit 10 — Sub-topics: VSEPR Theory, Sigma & Pi Bonds, Hybridization, Dipole Moment, Bond Energy

VSEPR Theory — predicting molecular shape

Valence Shell Electron Pair Repulsion (VSEPR) theory predicts a molecule's 3D shape based on one simple idea: electron pairs (bonding pairs and lone pairs) around a central atom repel each other and arrange themselves as far apart as possible to minimise repulsion. Lone pairs repel more strongly than bonding pairs, which can slightly compress bond angles.

Sigma and pi bonds — two ways to overlap

A sigma (σ) bond forms from direct, head-on overlap of orbitals along the axis joining two nuclei — every single covalent bond contains exactly one sigma bond, and it allows free rotation around that bond axis. A pi (π) bond forms from sideways overlap of unhybridised p-orbitals above and below the bond axis — found in double and triple bonds (in addition to the sigma bond), and it prevents free rotation around that bond.

Key Facts

Sigma (σ) bond	Head-on overlap; present in every single bond; allows rotation
Pi (π) bond	Sideways overlap; found in double/triple bonds; prevents rotation

Hybridization — mixing orbitals to explain shape

Hybridization is the mixing of atomic orbitals (like one s and some p orbitals) to form new, equivalent hybrid orbitals that better explain a molecule's observed bond angles and shape. sp^3 hybridisation gives a tetrahedral arrangement (109.5°, as in methane), sp^2 gives a trigonal planar arrangement (120°, as in ethene), and sp gives a linear arrangement (180°, as in ethyne).

Key Facts

sp^3	4 hybrid orbitals — tetrahedral, 109.5°
sp^2	3 hybrid orbitals — trigonal planar, 120°
sp	2 hybrid orbitals — linear, 180°

Dipole moment & bond energy

A dipole moment arises when a bond (or whole molecule) has an uneven distribution of charge — one end slightly negative, the other slightly positive — due to a difference in electronegativity between bonded atoms. A molecule's overall polarity depends on both individual bond dipoles AND molecular shape (symmetric molecules can cancel out bond dipoles and end up non-polar overall). Bond energy is the energy required to break one mole of a particular covalent bond; higher bond energy means a stronger, more stable bond.

Common Trap

A molecule can have polar bonds but still be non-polar overall (e.g., CO_2) if its symmetric shape causes the individual bond dipoles to cancel out.

60-Second Revision

- VSEPR: electron pairs repel and arrange to minimise repulsion, giving molecular shape
- Sigma bonds: head-on overlap, allow rotation; Pi bonds: sideways overlap, prevent rotation

- sp^3 = tetrahedral (109.5°); sp^2 = trigonal planar (120°); sp = linear (180°)
- Polarity depends on bond dipoles AND molecular shape — symmetric shapes can cancel dipoles

Quick Check

1. A double bond contains: A) Two sigma bonds B) One sigma and one pi bond C) Two pi bonds D) No sigma bonds
2. sp^3 hybridization gives which molecular shape? A) Linear B) Trigonal planar C) Tetrahedral D) Octahedral
3. A molecule with polar bonds can be non-polar overall if: A) It has no electrons B) Its shape causes bond dipoles to cancel C) It is a gas D) It has only single bonds

Answers: 1-B, 2-C, 3-B

11

S- and P-Block Elements

The main-group elements and their trends

PMDC Syllabus Unit 11 — Sub-topics: Periodic Properties & Trends, S/P/D/F-Block Demarcation, Reactions of Group I, II & IV Elements

Periodic trends — the patterns behind the table

Atomic radius generally decreases across a period (increasing nuclear charge pulls electrons in closer) and increases down a group (extra electron shells are added). Ionisation energy (energy to remove an electron) generally increases across a period and decreases down a group. Electronegativity (an atom's pull on shared electrons) follows the same trend as ionisation energy — increasing across a period, decreasing down a group.

Dividing up the periodic table

The periodic table is divided into blocks based on which sub-level the last electron is added to: s-block (Groups I and II — reactive metals), p-block (Groups III to VIII/0 — includes metals, non-metals, and metalloids), d-block (transition metals, in the middle), and f-block (lanthanides and actinides, usually shown separately at the bottom).

Reactions of Group I, II & IV elements

Group I elements (alkali metals, e.g., sodium) are extremely reactive: they react vigorously with water to release hydrogen gas and form a strongly alkaline hydroxide solution, react with oxygen to form oxides, and react with chlorine to form ionic chlorides. Group II elements (alkaline earth metals, e.g., calcium, magnesium) are also reactive but less so than Group I — they react more slowly with water (reactivity increases going down the group), and similarly form oxides with oxygen and chlorides with chlorine. Group IV elements show a gradual shift from non-metallic to metallic character going down the group (carbon is a non-metal, while tin and lead show increasingly metallic behaviour), which affects how strongly and in what way they react with these same substances.

Key Facts

Group I + water	Vigorous reaction → metal hydroxide + hydrogen gas
Group II + water	Slower, less vigorous reaction than Group I (reactivity increases down the group)
Both groups + oxygen/chlorine	Form oxides and chlorides respectively

60-Second Revision

- Atomic radius decreases across a period, increases down a group
- Ionisation energy & electronegativity increase across a period, decrease down a group
- s-block = Groups I & II; p-block = Groups III-VIII; d-block = transition metals; f-block = lanthanides/actinides
- Group I metals react vigorously with water; Group II less so; both form oxides/chlorides

Quick Check

1. Atomic radius generally decreases as you move: A) Down a group B) Across a period (left to right) C) Diagonally D) It never changes
2. Which block includes the alkali and alkaline earth metals? A) p-block B) d-block C) s-block D) f-block
3. Group I metals react with water to produce: A) An acid and oxygen B) A metal hydroxide and hydrogen gas C) A metal oxide only D) No reaction occurs

Answers: 1-B, 2-C, 3-B

12

Transition Elements

The colourful, versatile metals in the middle of the table

PMDC Syllabus Unit 12 — Sub-topics: Electronic Structure of d-Block Elements and Ions

Electronic structure of transition elements

Transition elements are d-block metals whose atoms (or common ions) have a partially filled d sub-level. Their electronic configurations typically fill the 4s sub-level before the 3d sub-level (following the Aufbau principle), but interestingly, when transition metal atoms form positive ions, electrons are removed from the 4s sub-level FIRST, before any 3d electrons — because once occupied, the 3d sub-level becomes lower in energy than 4s.

Key Facts

Filling order (neutral atom)	4s fills before 3d (Aufbau principle)
Ion formation	Electrons are lost from 4s BEFORE 3d, even though 4s filled first
Defining feature	A partially filled d sub-level in the atom or a common ion

MDCAT Tip

This '4s fills first, but empties first too' rule is one of the most frequently tested transition metal facts on MDCAT — make sure you have it the right way round!

60-Second Revision

- Transition elements are d-block metals with a partially filled d sub-level
- 4s sub-level fills before 3d in neutral atoms (Aufbau principle)
- But when forming ions, electrons are removed from 4s BEFORE 3d
- This defines much of transition metals' characteristic chemistry and variable oxidation states

Quick Check

1. Transition elements are characterised by having a: A) Full d sub-level always B) Partially filled d sub-level C) Empty d sub-level D) No d sub-level
2. When a transition metal atom forms a positive ion, electrons are first removed from: A) 3d B) 4s C) 3p D) 4p
3. Which sub-level fills first in a neutral transition metal atom according to the Aufbau principle? A) 3d B) 4s C) 4p D) 3p

Answers: 1-B, 2-B, 3-B

13

Fundamentals of Organic Chemistry

The chemistry of carbon — the backbone of life

PMDC Syllabus Unit 13 — Sub-topics: Definition & Classification of Organic Compounds, Functional Groups, Isomerism

What is organic chemistry?

Organic chemistry is the study of carbon-containing compounds (with a few exceptions like carbon dioxide and carbonates, which are considered inorganic). Carbon's unique ability to form four strong covalent bonds — including long chains and rings with itself — explains the huge diversity of organic compounds. Organic compounds are classified structurally as aliphatic (open-chain, like alkanes) or aromatic (containing a benzene-type ring), and further as saturated (only single bonds) or unsaturated (containing double or triple bonds).

Functional groups — the 'reactive address' of a molecule

A functional group is a specific atom or group of atoms within a molecule that is largely responsible for its characteristic chemical behaviour, regardless of the rest of the carbon chain it's attached to. For example, the -OH group makes a compound an alcohol, and the -COOH group makes it a carboxylic acid — recognising the functional group lets you predict how a compound will react.

Isomerism — same formula, different structure

Isomers are compounds with the same molecular formula but different arrangements of atoms. Stereoisomerism specifically means isomers have the same atom-to-atom bonding sequence, but differ in how their atoms are arranged in 3D space. Its two main types are geometric (cis-trans) isomerism, which arises from restricted rotation around a double bond, and optical isomerism, which arises when a carbon atom is bonded to four different groups (a 'chiral centre'), producing non-superimposable mirror-image molecules.

Key Facts

Geometric (cis-trans) isomerism	Due to restricted rotation around a C=C double bond
Optical isomerism	Due to a chiral carbon bonded to 4 different groups — produces mirror-image forms

60-Second Revision

- Organic chemistry = chemistry of carbon compounds (mostly)
- Compounds classified as aliphatic/aromatic and saturated/unsaturated
- A functional group determines a molecule's characteristic reactivity
- Stereoisomerism: geometric (cis-trans, from C=C) and optical (from a chiral carbon) isomerism

Quick Check

1. Organic chemistry is mainly the study of compounds containing: A) Nitrogen B) Carbon C) Oxygen D) Sulfur
2. The -OH functional group characterises which class of compounds? A) Carboxylic acids B) Alcohols C) Aldehydes D) Alkanes
3. Geometric (cis-trans) isomerism arises due to restricted rotation around a: A) Single bond B) Triple bond C) Double bond D) Ionic bond

Answers: 1-B, 2-B, 3-C

14

Chemistry of Hydrocarbons

Alkanes, alkenes, alkynes & benzene — carbon's simplest compounds

PMDC Syllabus Unit 14 — Sub-topics: Alkanes (Nomenclature, Free Radical Mechanism), Alkenes (Structure, Reactivity, Preparation), Benzene (MOT, Resonance, Reactions), Alkynes (Nomenclature, Preparation, Acidity, Reactions)

Alkanes & free radical substitution

Alkanes are saturated hydrocarbons (only single C-C and C-H bonds), named using IUPAC rules based on the longest carbon chain. Alkanes react with halogens via a free radical substitution mechanism, requiring UV light or heat to start. This mechanism has three stages: initiation (UV light splits a halogen molecule into two highly reactive free radicals), propagation (radicals react with alkane molecules in a repeating chain of steps, each regenerating a new radical), and termination (two radicals combine, ending the chain).

Alkenes — the double-bond family

Alkenes are unsaturated hydrocarbons containing at least one C=C double bond (one sigma + one pi bond), which makes them far more reactive than alkanes — they readily undergo addition reactions (across the double bond) rather than substitution. Alkenes can be prepared by dehydration of alcohols (removing water) or dehydrohalogenation of alkyl halides (removing a hydrogen halide), both elimination reactions.

Benzene — a special, extra-stable ring ⬡

Benzene's true structure (explained by molecular orbital theory) is a flat hexagonal ring where all six p-orbital electrons are delocalised equally around the whole ring, rather than existing as three fixed alternating double bonds. This delocalisation gives benzene extra stability called resonance energy, making it much less reactive toward addition reactions than a typical alkene, and it instead favours electrophilic substitution reactions (like nitration, sulphonation, halogenation, and Friedel-Crafts alkylation/acylation) which preserve its stable ring.

Key Facts

Benzene structure	Flat hexagonal ring with delocalised electrons (not 3 fixed double bonds)
Resonance energy	Extra stability from electron delocalisation
Typical reaction type	Electrophilic substitution — NOT addition

Common Trap

Don't expect benzene to react like a typical alkene (via addition) — its delocalised ring structure makes substitution reactions far more favourable, preserving its stability.

Alkynes — the triple-bond family

Alkynes contain at least one C≡C triple bond and are named with the '-yne' suffix. They can be prepared via elimination reactions (e.g., removing two molecules of hydrogen halide from a dihalide). A terminal alkyne (with a C≡C-H at the end of the chain) is weakly acidic — that hydrogen can be removed by a strong base, because the resulting carbanion is stabilised by the high s-character of the sp-hybridised carbon. Like alkenes, alkynes undergo addition reactions such as hydrogenation, hydrohalogenation, and hydration.

60-Second Revision

- Alkanes react with halogens via free radical substitution: initiation → propagation → termination

- Alkenes (C=C) are more reactive than alkanes and mainly undergo addition reactions
- Benzene's delocalised ring gives it resonance energy — it favours substitution, not addition
- Alkynes (C≡C) undergo addition reactions; terminal alkynes are weakly acidic

Quick Check

1. The first stage of free radical substitution, where UV light splits a halogen molecule, is called: A) Termination B) Propagation C) Initiation D) Addition
2. Benzene mainly undergoes which type of reaction? A) Addition B) Electrophilic substitution C) Reduction D) Hydrolysis
3. A terminal alkyne is weakly acidic because: A) It has a double bond B) Its carbanion is stabilised by high s-character of the sp carbon C) It contains oxygen D) It is aromatic

Answers: 1-C, 2-B, 3-B

15

Alkyl Halides

Carbon chains with a halogen 'handle' for reactions

PMDC Syllabus Unit 15 — Sub-topics: Nomenclature, Structure & Reactivity, Substitution vs Elimination Reactions

Structure & reactivity of alkyl halides (R-X)

An alkyl halide (R-X) is a hydrocarbon chain with one or more halogen atoms (F, Cl, Br, I) attached. Because the carbon-halogen bond is polar (halogen is more electronegative), the carbon attached to the halogen carries a partial positive charge, making it an attractive target for attack by electron-rich species — this is what drives most of alkyl halide chemistry.

Nucleophilic substitution reactions

In a nucleophilic substitution reaction, a nucleophile (an electron-rich species) attacks the carbon bonded to the halogen, and the halogen leaves as a halide ion — the nucleophile takes its place. This can happen in two ways: SN1 (a two-step mechanism via a carbocation intermediate, favoured by bulky/tertiary alkyl halides) or SN2 (a one-step mechanism where the nucleophile attacks as the halide leaves simultaneously, favoured by simple/primary alkyl halides).

Elimination reactions

In an elimination reaction, instead of being replaced, the halogen leaves along with a hydrogen atom from a neighbouring carbon, forming a new C=C double bond (an alkene) as the product. Just like substitution, elimination can proceed via E1 (stepwise, carbocation intermediate) or E2 (one-step) mechanisms.

Key Facts

Substitution (SN1/SN2)	Halogen replaced by a nucleophile — product keeps similar structure
Elimination (E1/E2)	Halogen (and a neighbouring H) removed — forms a C=C double bond (alkene)

MDCAT Tip

Whether substitution or elimination dominates often depends on conditions: strong bases and heat favour elimination, while good nucleophiles in mild conditions favour substitution.

60-Second Revision

- Alkyl halides (R-X) have a polar C-X bond, making carbon susceptible to nucleophilic attack
- Nucleophilic substitution: nucleophile replaces the halogen (SN1 = 2-step; SN2 = 1-step)
- Elimination: halogen + neighbouring H removed, forming a C=C double bond (E1/E2)
- Conditions (base strength, heat) determine whether substitution or elimination dominates

Quick Check

1. In a nucleophilic substitution reaction, the halogen atom is: A) Added to the molecule B) Replaced by a nucleophile C) Converted to a double bond D) Unaffected
2. An elimination reaction on an alkyl halide typically produces: A) An alcohol B) An alkene C) An alkane D) A carboxylic acid
3. SN2 reactions proceed via which type of mechanism? A) Two-step, via carbocation B) One-step, simultaneous attack and leaving C) No mechanism D) Radical mechanism

Answers: 1-B, 2-B, 3-B

16

Alcohols & Phenols

Two families built around the -OH group, with very different personalities

PMDC Syllabus Unit 16 — Sub-topics: Nomenclature, Structure & Reactivity of Alcohols and Phenols

Alcohols — versatile -OH compounds

An alcohol has an -OH group attached to a saturated carbon chain (named with the '-ol' suffix). Because of the polar O-H bond and the oxygen's lone pairs, alcohols can act as both a nucleophile and an acid (very weakly). They react to form ethers (by combining two alcohol molecules with loss of water) and esters (by reacting with a carboxylic acid, releasing water — esterification).

Phenols — an -OH group directly on a benzene ring ⬡

A phenol has an -OH group attached directly to an aromatic (benzene) ring. Because the ring's delocalised electrons interact with the oxygen's lone pair, phenols are significantly more acidic than alcohols — they can lose the H^+ from -OH more easily since the resulting phenoxide ion is stabilised by resonance with the ring. Phenols also react through electrophilic aromatic substitution (like benzene) because the -OH group activates the ring, making it more reactive to electrophiles.

Key Facts

Alcohols	-OH on a saturated chain — form ethers/esters, weakly acidic
Phenols	-OH directly on a benzene ring — significantly more acidic, undergo electrophilic aromatic substitution

Common Trap

Don't assume alcohols and phenols behave identically just because both have -OH — phenols are far more acidic and react differently (aromatic substitution) due to the attached benzene ring.

60-Second Revision

- Alcohols: -OH on a saturated carbon chain; can form ethers and esters
- Phenols: -OH directly on a benzene ring — much more acidic than alcohols
- Phenol's acidity comes from resonance stabilisation of the phenoxide ion by the ring
- Phenols undergo electrophilic aromatic substitution; alcohols do not (no aromatic ring)

Quick Check

1. Which compound is more acidic? A) Ethanol B) Phenol C) They are equally acidic D) Neither is acidic
2. The reaction between an alcohol and a carboxylic acid, releasing water, is called: A) Hydrolysis B) Esterification C) Oxidation D) Substitution
3. Phenols react via electrophilic aromatic substitution because: A) They have no ring B) The -OH group activates the aromatic ring C) They contain no oxygen D) They are saturated only

Answers: 1-B, 2-B, 3-B

17

Aldehydes & Ketones

The carbonyl (C=O) family — reactive and everywhere in biology

PMDC Syllabus Unit 17 — Sub-topics: Nomenclature & Structure, Preparation, Reactivity, Nucleophilic Addition, Reduction & Oxidation Reactions

What makes the carbonyl group so reactive?

Both aldehydes (R-CHO, with the carbonyl carbon at the end of the chain, bonded to at least one hydrogen) and ketones (R-CO-R', with the carbonyl carbon between two carbon groups) contain a polar C=O (carbonyl) double bond. Because oxygen is more electronegative, the carbon carries a partial positive charge — making it an excellent target for attack by nucleophiles.

Preparation & nucleophilic addition reactions

Aldehydes and ketones are commonly prepared by the oxidation of alcohols (primary alcohols give aldehydes; secondary alcohols give ketones). Their key reaction type is nucleophilic addition: a nucleophile attacks the positive carbonyl carbon, the C=O pi bond breaks, and the oxygen picks up a negative charge (later protonated) — this can be acid-catalysed (the carbonyl oxygen is first protonated, making the carbon even more electrophilic) or base-catalysed (the nucleophile itself is more reactive).

Reduction & oxidation — reversing and extending the chemistry

Aldehydes and ketones can be reduced back to alcohols (aldehydes → primary alcohols; ketones → secondary alcohols) using a reducing agent — essentially the reverse of their preparation. Aldehydes can be further oxidised to carboxylic acids relatively easily (since they still have an H on the carbonyl carbon to lose), while ketones strongly resist oxidation under normal conditions (there's no such H available) — this difference is a classic chemical test to distinguish the two.

Key Facts

Aldehyde	R-CHO; oxidises easily to a carboxylic acid; reduces to a primary alcohol
Ketone	R-CO-R'; resists oxidation; reduces to a secondary alcohol

MDCAT Tip

MDCAT loves this distinguishing test: aldehydes are easily oxidised (e.g., they reduce Tollens'/Fehling's reagent), but ketones are not — a reliable way to tell the two apart chemically.

60-Second Revision

- Both aldehydes and ketones contain a reactive, polar C=O (carbonyl) group
- Aldehyde: carbonyl carbon at chain end (has an H); Ketone: carbonyl carbon between two C groups
- Key reaction type: nucleophilic addition (acid- or base-catalysed) at the carbonyl carbon
- Aldehydes oxidise easily to carboxylic acids; ketones strongly resist oxidation

Quick Check

1. Which functional group is common to both aldehydes and ketones? A) -OH B) C=O (carbonyl) C) -COOH D) -NH2
2. Which of these is more easily oxidised? A) Ketone B) Aldehyde C) Both equally D) Neither
3. Reduction of a ketone produces a: A) Primary alcohol B) Secondary alcohol C) Carboxylic acid D) Alkene

Answers: 1-B, 2-B, 3-B

18

Carboxylic Acids

The 'true acids' of organic chemistry

PMDC Syllabus Unit 18 — Sub-topics: Nomenclature, Structure & Preparation, Reactivity, Conversion to Derivatives

Structure and acidity of carboxylic acids

A carboxylic acid contains the -COOH functional group — essentially a carbonyl (C=O) and a hydroxyl (-OH) group on the same carbon. This combination makes carboxylic acids genuinely acidic (much more so than alcohols or phenols): the O-H bond can release H^+, and the resulting carboxylate ion is strongly stabilised by resonance shared equally across both oxygen atoms.

Reactivity & conversion to derivatives

Carboxylic acids can be converted into a family of related 'derivative' compounds by replacing the -OH group: acyl halides (replacing -OH with a halogen — very reactive), acid anhydrides (two carboxylic acid units joined with loss of water), and esters (formed with an alcohol, releasing water — esterification). Each derivative can, in turn, often be converted back into the carboxylic acid (or into other derivatives) through appropriate reactions such as hydrolysis.

Key Facts

Acyl halide	-COOH → -COX (very reactive derivative)
Acid anhydride	Two carboxylic acids joined, losing water
Ester	Carboxylic acid + alcohol → ester + water (esterification)

MDCAT Tip

Reactivity order of these derivatives (most to least reactive) generally follows: acyl halide > acid anhydride > ester > carboxylic acid itself — useful for predicting which reacts fastest with a given nucleophile.

60-Second Revision

- Carboxylic acids (-COOH) are genuinely acidic due to resonance-stabilised carboxylate ions
- -COOH can be converted into acyl halides, acid anhydrides, and esters
- Esterification: carboxylic acid + alcohol → ester + water
- Derivative reactivity order: acyl halide > acid anhydride > ester > carboxylic acid

Quick Check

1. The functional group of a carboxylic acid is: A) -OH B) -COOH C) C=O only D) -CHO
2. Esterification is the reaction between a carboxylic acid and a(n): A) Alkane B) Alcohol C) Aldehyde D) Alkyl halide
3. Which carboxylic acid derivative is generally the MOST reactive? A) Ester B) Acid anhydride C) Acyl halide D) The acid itself

Answers: 1-B, 2-B, 3-C

19

Macromolecules

Giant molecules built from repeating units — especially proteins

PMDC Syllabus Unit 19 — Sub-topics: Classification of Proteins, Importance of Proteins, Enzymes as Biocatalysts

Classifying proteins & structure-function relationship

Proteins are macromolecules built from long chains of amino acids, folded into specific 3D shapes. They can be classified structurally (fibrous proteins, like collagen, which are long and strand-like, providing structural support; or globular proteins, like enzymes and haemoglobin, which are compact and folded, suited to specific functional roles) or by function (structural, transport, enzymatic, hormonal, and so on). A protein's specific shape determines its specific function — even a small change in shape can destroy its ability to work.

Why proteins matter for the body

Proteins serve countless roles in maintaining body function: structural proteins (like collagen and keratin) build tissues; transport proteins (like haemoglobin) carry substances around the body; enzymes catalyse metabolic reactions; antibodies defend against pathogens; and many hormones are proteins too. Nutritionally, proteins supply the essential amino acids the body cannot make on its own, needed for growth and tissue repair.

Enzymes as biocatalysts

Enzymes are a special class of globular proteins that act as biological catalysts (biocatalysts) — speeding up biochemical reactions inside living organisms without being consumed themselves, by lowering the activation energy of the reaction (linking back to the Reaction Kinetics unit). This makes reactions that would otherwise be far too slow for life proceed quickly enough to sustain living processes.

60-Second Revision

- Proteins = chains of amino acids folded into a specific 3D shape
- Classified as fibrous (structural) or globular (functional, e.g. enzymes, haemoglobin)
- Proteins play structural, transport, enzymatic, hormonal & nutritional roles in the body
- Enzymes are protein biocatalysts that lower activation energy to speed up biochemical reactions

Quick Check

1. Fibrous proteins are best described as: A) Compact and folded B) Long, strand-like, structural C) Always enzymes D) Only found in plants
2. Which protein transports substances in the blood? A) Collagen B) Haemoglobin C) Keratin D) Insulin only
3. Enzymes act as biocatalysts mainly by: A) Increasing activation energy B) Lowering activation energy C) Adding mass to reactants D) Changing reaction products permanently

Answers: 1-B, 2-B, 3-B

20

Industrial Chemistry

Chemistry that builds the products around you

PMDC Syllabus Unit 20 — Sub-topics: Adhesives, Dyes, Polymers

Adhesives — chemistry that sticks things together

An adhesive is a substance used to bind two surfaces together through a combination of chemical bonding and/or physical attraction. Different adhesives are suited to different applications depending on the materials being joined, the strength required, and conditions like moisture or temperature — ranging from natural adhesives to synthetic, polymer-based glues.

Dyes — chemistry that adds colour

A dye is a coloured substance that chemically bonds to (or is absorbed by) a material, giving it lasting colour — unlike a pigment, which typically just sits on the surface. Different types of dyes suit different materials (natural fibres like cotton and wool versus synthetic fibres), and their use spans textiles, food, and countless everyday products.

Polymers — long chains built from repeating units

A polymer is a large molecule made of many repeating smaller units (monomers) joined together. Addition polymers form when monomers containing a C=C double bond join together directly, one after another, with no other product formed (e.g., polyethylene from ethene monomers). Condensation polymers form when monomers join together with the loss of a small molecule (usually water) at each linkage, typically because each monomer has two reactive functional groups (e.g., nylon, formed from a diamine and a diacid).

Key Facts

Addition polymers	Formed from monomers with C=C bonds joining directly; no by-product (e.g., polyethylene)
Condensation polymers	Formed with loss of a small molecule (e.g., water) at each link (e.g., nylon)

MDCAT Tip

A quick way to sort exam questions: if a small molecule like water is released during polymerisation, it's a condensation polymer; if nothing is released, it's an addition polymer.

60-Second Revision

- Adhesives bind surfaces via chemical bonding and/or physical attraction
- Dyes chemically bond to materials to give lasting colour (unlike surface pigments)
- Addition polymers: monomers with C=C join directly, no by-product (e.g., polyethylene)
- Condensation polymers: monomers join with loss of a small molecule like water (e.g., nylon)

Quick Check

1. Addition polymerisation requires monomers containing a: A) -COOH group B) C=C double bond C) -OH group only D) Benzene ring only
2. Condensation polymerisation typically releases which small molecule? A) Oxygen B) Water C) Nitrogen D) Hydrogen
3. Which is an example of a condensation polymer? A) Polyethylene B) Polypropylene C) Nylon D) Polystyrene

Answers: 1-B, 2-B, 3-C

All 20 Units Complete!

You've now revised every Chemistry sub-topic that PMDC lists across all 20 units (25% weightage, 45 MCQs) of the MDCAT paper. Go back through each Key Facts box, retake every Quick Check, and keep a close eye on the Common Traps — they are the exact spots where MDCAT candidates lose easy marks. Best of luck on your MDCAT journey!

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MDCAT TEST PREPARATION

PHYSICS

Revision Guide — Strictly Mapped to the Official PMDC MDCAT Syllabus

Every topic taken directly from PMDC's official MDCAT curriculum
Explained from the prescribed textbook, in simple MDCAT language
Formula boxes, tips, common traps & quick-check MCQs

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Contents

Built unit-by-unit from PMDC's MDCAT 2025 Physics syllabus (Section 3)

How to use this book: Each unit follows the exact sub-topics listed in PMDC's official MDCAT curriculum document — nothing extra, nothing skipped. Every "LO" tag you see refers to the matching Learning Outcome number in the official syllabus, so you can cross-check instantly. Read the concept, lock in the formula box, dodge the trap box, and test yourself with the quick-check MCQs.

1 Vectors and Equilibrium

Quantities with both a size AND a direction

PMDC Syllabus Unit 1 — Sub-topics: Addition of Vectors (Rectangular Components) • Product of Vectors (Scalar Product) • Product of Vectors (Vector Product)

Addition of Vectors — Rectangular Components LO 1.1

Telling someone "walk 5 metres" is only half the story — 5 metres in which direction? A **vector** quantity (displacement, velocity, force) needs both a magnitude AND a direction, unlike a **scalar** (mass, time, speed), which is fully described by a number alone.

The smartest way to add several vectors together is to break each one into two perpendicular pieces first — its **x-component** and **y-component** — using simple trigonometry. If a vector **A** makes angle θ with the x-axis: $Ax = A\cos\theta$ and $Ay = A\sin\theta$. Once every vector is broken into x and y pieces, you simply add all the x's together and all the y's together to get the resultant's components — no messy diagrams needed.

KEY FORMULAS

Rectangular components	$\mathbf{Ax = A\cos\theta,\ \ Ay = A\sin\theta}$
Magnitude of resultant	$\mathbf{R = \sqrt{(Rx^2 + Ry^2)}}$
Direction of resultant	$\mathbf{\theta = \tan^{-1}(Ry / Rx)}$

Product of Vectors — Scalar Product LO 1.2

The **scalar (dot) product** of two vectors multiplies their magnitudes along with the cosine of the angle between them: $A \cdot B = AB\cos\theta$. The result is always a plain number (a scalar), never a vector. This is exactly how **work** is defined in physics: W = F · d = Fd cos θ.

MDCAT Tip: If A · B = 0 (and neither vector is zero), the vectors must be perpendicular, since cos 90° = 0. This single fact solves many "what can you conclude" MCQs instantly.

Product of Vectors — Vector Product LO 1.3

The **vector (cross) product** multiplies the magnitudes with the sine of the angle between them, and — unlike the dot product — the result is itself a brand-new vector, perpendicular to both original vectors: $A \times B = AB\sin\theta$, with direction found using the right-hand rule. Torque is defined this way: τ = r × F.

KEY FORMULAS

Scalar (dot) product	$\mathbf{A \cdot B = AB\cos\theta}$ **(a scalar)**
Vector (cross) product	$\mathbf{\lvert A \times B\rvert = AB\sin\theta}$ **(a new vector)**

Common Trap: Don't mix up the two products in MCQs — dot product gives a scalar answer (used for Work), cross product gives a vector answer (used for Torque). If A × B = 0, the vectors are parallel or anti-parallel (sin 0° = sin 180° = 0) — the opposite condition to the dot product rule!

60-Second Revision

- Resolve any vector using $A_x = A\cos\theta$, $A_y = A\sin\theta$, then add components separately
- $R = \sqrt{(R_x^2 + R_y^2)}$; direction $\theta = \tan^{-1}(R_y/R_x)$
- Dot product → scalar, $A\cdot B = AB\cos\theta$ (Work uses this)
- Cross product → vector, $A\times B = AB\sin\theta$ (Torque uses this)

QUICK CHECK

1. If a vector A = 10 units at 30° to the x-axis, its x-component is closest to:
   A) 5 B) 8.7 C) 10 D) 3
2. If $A \cdot B = 0$ (neither vector is zero), the angle between A and B is:
   A) 0° B) 45° C) 90° D) 180°
3. Which quantity is calculated using the vector (cross) product?
   A) Work B) Torque C) Power D) Energy

Answers: 1-B, 2-C, 3-B

END OF UNIT 1 — EXAMOO

2 Force and Motion

Why things move, speed up, fly through the air, and collide

PMDC Syllabus Unit 2 — Sub-topics: Displacement, Velocity, Displacement-time Graph, Acceleration, Uniform/Variable Acceleration, Projectile Motion, Newton's Laws, Linear Momentum, Collisions, Explosive Forces, Perfectly Elastic Collision

Displacement, Velocity & Acceleration LO 2.1–2.5

Displacement is the straight-line distance and direction from a starting point to an ending point — a vector. **Average velocity** is displacement divided by the time taken. On a **displacement-time graph**, the slope at any point tells you the velocity at that instant — a steeper slope means faster motion, a flat line means the object is at rest.

Acceleration is the rate of change of velocity. When acceleration stays the same value throughout the motion, it is called **uniform acceleration**; when it keeps changing, it's **variable acceleration**. Only uniform acceleration allows the use of the standard equations of motion.

Projectile Motion LO 2.6–2.11

A **projectile** is any object launched into the air and then left to move freely under gravity alone — its path is two-dimensional, curving through a vertical plane. For an **ideal projectile** (no air resistance), the motion splits neatly into two independent parts: a **horizontal component** of velocity that stays constant throughout the flight (no horizontal force acts on it), and a **vertical component** that accelerates downward exactly like a freely falling body (a = g, downward).

PROJECTILE MOTION FORMULAS (launched at angle θ, speed v_0, from ground level)

Maximum height	$\mathbf{H = v_0^2 \sin^2\theta / 2g}$
Time of flight	$\mathbf{T = 2v_0 \sin\theta / g}$
Horizontal range	$\mathbf{R = v_0^2 \sin 2\theta / g}$
Angle for maximum range	$\mathbf{\theta = 45^\circ}$

MDCAT Tip: Two different launch angles that add up to 90° (like 30° and 60°) give the exact same horizontal range — because sin 2θ is the same for θ and (90° - θ). This symmetry is a favourite MDCAT numerical setup.

Newton's Laws & Linear Momentum LO 2.12–2.14

Newton's First Law (Inertia): a body stays at rest or keeps moving with constant velocity unless acted on by a net (unbalanced) force. **Newton's Second Law** is best understood as the rate of change of momentum: $F = \Delta p/\Delta t$, which reduces to the familiar F = ma when mass stays constant. **Newton's Third Law:** every action force has an equal and opposite reaction force, and — crucially — this pair acts on two *different* bodies, so the forces never cancel on the same object.

Definition: **Linear momentum (p = mv)** connects directly to Newton's Third Law: when two isolated bodies interact (collide or push apart), the momentum lost by one exactly equals the momentum gained by the other — giving the **Law of Conservation of Momentum**.

Collisions, Explosive Forces & Perfectly Elastic Collision LO 2.15–2.17

In any collision — as long as no external force interferes — total momentum is always conserved. In an **elastic collision**, kinetic energy is conserved too; in an **inelastic collision**, it is not (some energy converts to heat, sound, or deformation). **Explosive forces** (like a firecracker splitting a can into pieces) also conserve momentum — the pieces fly apart so that their combined momentum still adds up to what it was before the explosion (usually zero, if the system started at rest).

For a **perfectly elastic collision in one dimension** between masses m_1 and m_2, combining conservation of momentum with conservation of kinetic energy leads to an elegant result: the relative velocity of approach before collision equals the relative velocity of separation after collision, just reversed in sign — $(v_1 - v_2) = -(v_1' - v_2')$. In other words, the magnitude of relative velocity of approach equals the magnitude of relative velocity of separation.

KEY FORMULAS

Linear momentum	$\mathbf{p = mv}$
Newton's 2nd Law (general form)	$\mathbf{F = \Delta p/\Delta t}$
Elastic collision — velocity after (body 1)	$\mathbf{v_1' = [(m_1-m_2)/(m_1+m_2)]v_1 + [2m_2/(m_1+m_2)]v_2}$
Elastic collision — velocity after (body 2)	$\mathbf{v_2' = [2m_1/(m_1+m_2)]v_1 + [(m_2-m_1)/(m_1+m_2)]v_2}$
Relative speed rule (elastic collision)	**speed of approach = speed of separation**

Common Trap: When $m_1 = m_2$ in a 1-D elastic collision and body 2 starts at rest, the equations show that body 1 stops completely and body 2 moves off with body 1's original velocity — a classic "billiard ball" MCQ setup students often get backwards.

60-Second Revision

- Projectile: horizontal velocity constant, vertical velocity accelerates at g
- Max range at θ = 45°; complementary angles (θ and 90°-θ) give equal range
- Newton's 2nd Law: F = Δp/Δt (more general than F = ma)
- Elastic collision: both momentum and KE conserved; speed of approach = speed of separation

QUICK CHECK

1. In projectile motion (no air resistance), the horizontal component of velocity:
   A) Increases B) Decreases C) Remains constant D) Becomes zero at the top
2. A projectile launched at 30° has the same range as one launched at:
   A) 30° B) 45° C) 60° D) 90°
3. In a perfectly elastic 1-D collision, the relative velocity of approach is:

A) Always zero B) Equal to the relative velocity of separation C) Double the separation speed D) Unrelated to separation speed

Answers: 1-C, 2-C, 3-B

END OF UNIT 2 — EXAMOO

3 Work and Energy

The currency the universe uses to get things done

PMDC Syllabus Unit 3 — Sub-topics: Work, Energy, Kinetic Energy, Potential Energy, Absolute Potential Energy, Power, Work-Energy Theorem in a Resistive Medium, Energy Losses & Efficiency

Work, Kinetic & Potential Energy LO 3.1–3.4

Work is done only when a force actually causes displacement in the direction of that force: $W = Fd\cos\theta$. Push against a wall for an hour and it doesn't move — physics says you've done zero work, however tired you feel!

Kinetic energy is the energy a body has due to motion: $KE = \frac{1}{2}mv^2$. **Potential energy** is stored energy due to position; near Earth's surface, gravitational PE = mgh. It's important to distinguish potential energy in general from gravitational potential energy specifically — PE can also be stored in a stretched spring, a charged capacitor, or a compressed gas.

Absolute Potential Energy LO 3.5

The formula PE = mgh only works near Earth's surface, where gravity is approximately constant. But gravity actually weakens with distance (inverse-square law), so for large distances we need a more general idea: **absolute gravitational potential energy** — the work done by gravity in moving an object from a given position all the way out to infinity, where the gravitational force finally drops to zero.

Definition: The absolute gravitational potential energy of a mass m at distance r from Earth's centre is **U = -GMm/r**. The negative sign simply reflects that gravity is an attractive force — as r increases, U becomes less negative (i.e., increases), matching the everyday fact that lifting an object higher increases its PE. The reference (zero PE) point is chosen at infinity, but only the *difference* in PE between two points ever has physical meaning.

Power, Work-Energy Theorem & Efficiency LO 3.6–3.8

Power is the rate of doing work, and can be written as the scalar product of force and velocity: $P = F \cdot v$. In a **resistive medium** (like air or a rough surface), work done against friction doesn't disappear — the work-energy theorem shows it is simply dissipated as heat into the surroundings, which is why your hands warm up when you rub them together.

In real machines, some input energy is always "lost" to friction, sound, or heat — this is why no practical device is 100% efficient. **Efficiency** compares useful output energy to total input energy, and understanding these energy losses is essential for designing better engines, motors, and everyday devices.

KEY FORMULAS

Work	**W = Fd cos θ**
Kinetic energy	**KE = ½mv²**

Gravitational PE (near Earth's surface)	**PE = mgh**
Absolute gravitational PE	**U = -GMm/r**
Power	**P = W/t = F · v**
Efficiency	**η = (useful output / total input) × 100%**

MDCAT Tip: The absolute PE formula U = -GMm/r is always negative for a bound system — this negative sign is exactly what tells you energy must be added to pull the object free of the gravitational field (relevant to escape velocity questions).

Common Trap: If the force is perpendicular to displacement (θ = 90°), the work done is ZERO — even if a huge force is applied! Carrying a bag at constant height while walking horizontally does zero work against gravity in the physics sense.

60-Second Revision

- Work = Fd cos θ; zero work if force ⊥ displacement
- KE = ½mv²; PE = mgh (near surface) or U = -GMm/r (absolute, general)
- Power P = F·v; work against friction converts to heat (work-energy theorem in resistive medium)
- No real device is 100% efficient — energy losses are unavoidable

QUICK CHECK

1. The absolute gravitational potential energy of a mass at distance r from Earth's centre is given by:
   A) mgh B) -GMm/r C) ½mv² D) GMm/r²
2. Power can be expressed as the scalar product of force and:
   A) Displacement B) Time C) Velocity D) Acceleration
3. Work done against friction in a resistive medium is ultimately converted into:
   A) Potential energy B) Heat C) Momentum D) Nothing — it disappears

Answers: 1-B, 2-C, 3-B

END OF UNIT 3 — EXAMOO

4 Rotational and Circular Motion

Connecting the "straight-line world" to the "spinning world"

PMDC Syllabus Unit 4 — Sub-topics: Angular Displacement, Angular Velocity, Relation Between Angular and Linear Quantities

Angular Displacement LO 4.1–4.2

When an object moves along a circular path, it's often more convenient to describe its motion using angles rather than straight-line distances. **Angular displacement (θ)** is the angle swept out by the object as it moves around the circle, and it is measured in **radians** — the SI unit for angle. One full **revolution** corresponds to 360°, which is equal to 2π radians.

Definition: One **radian** is the angle subtended at the centre of a circle by an arc whose length equals the radius of that circle. This direct link between arc length and radius is exactly what makes radians so useful for connecting angular and linear motion.

Angular Velocity LO 4.3

Angular velocity (ω) is the rate at which angular displacement changes with time — essentially, how fast an object is sweeping through angle. A record spinning faster has a higher ω, even if its edge and centre are moving at very different linear speeds.

Relation Between Angular and Linear Quantities LO 4.4

Every point on a rotating object shares the same angular displacement and angular velocity, but points further from the centre move faster in a straight-line (linear) sense — think of a merry-go-round, where a child sitting at the edge covers far more actual distance per second than a child sitting near the centre, even though both complete the same number of rotations. This gives us simple relations linking the "angular world" to the "linear world":

KEY FORMULAS (r = radius of the circular path)

Angular displacement ↔ linear displacement	**$s = r\theta$**
Angular velocity ↔ linear velocity	**$v = r\omega$**
Angular acceleration ↔ linear (tangential) acceleration	**$a = r\alpha$**
1 revolution	**$360° = 2\pi$ radians**

MDCAT Tip: Because v = rω, two points on the same rotating disc always share the same ω, but the point further from the centre (larger r) always has the greater linear speed v. This distinction is a favourite MDCAT trick question.

Common Trap: Don't confuse angular velocity (ω, same for every point on a rigid rotating body) with linear velocity (v, different for every point depending on its distance from the axis). Students often assume all points on a spinning wheel move at the same speed — they don't!

60-Second Revision

- 1 revolution = 360° = 2π radians
- 1 radian = angle where arc length equals the radius
- Angular velocity ω is the same for every point on a rigid rotating body
- Linear-angular links: $s = r\theta$, $v = r\omega$, $a = r\alpha$

QUICK CHECK

1. One complete revolution is equal to how many radians?
   A) π B) 2π C) π/2 D) 4π
2. Two points lie on the same rotating disc, one near the centre and one near the edge. Which quantity is the SAME for both points?
   A) Linear velocity B) Angular velocity C) Linear speed D) Distance travelled
3. The relation between linear velocity and angular velocity is:
   A) $v = r\omega$ B) $v = r/\omega$ C) $v = \omega/r$ D) $v = r + \omega$

Answers: 1-B, 2-B, 3-A

END OF UNIT 4 — EXAMOO

5 Fluid Dynamics

How liquids and gases flow — and why this matters for blood physics too

PMDC Syllabus Unit 5 — Sub-topics: Terminal Velocity, Fluid Drag, Fluid Flow, Equation of Continuity, Bernoulli's Equation

Terminal Velocity & Fluid Drag LO 5.1–5.2

When an object falls through a fluid (like a ball bearing sinking through oil), the fluid resists its motion — this resistance is called **fluid drag**. As the object speeds up, drag grows stronger, until eventually drag force exactly balances the object's weight. At that point, acceleration becomes zero and the object continues falling at a constant speed called its **terminal velocity**.

Fluid Flow LO 5.3–5.5

Physics usually studies an idealized fluid to keep the maths manageable. **Steady (streamline or laminar) flow** means every fluid particle follows a smooth, predictable path, with the pattern of flow not changing over time. **Incompressible flow** assumes the fluid's density stays constant, and **non-viscous flow** assumes there's no internal friction within the fluid.

At sufficiently high velocity, though, real viscous fluid flow undergoes a transition from smooth laminar flow into chaotic **turbulence** — swirling, unpredictable motion. In fact, most real-world examples of fluid flow and resistance to motion actually involve turbulent rather than laminar conditions, even though the idealized laminar model is what the maths is built on.

Equation of Continuity LO 5.6–5.7

Squeeze a hose and the water shoots out faster — because the same mass of fluid must pass every cross-section of the pipe every second (assuming the fluid is ideal and incompressible). This gives the **equation of continuity: Av = constant**. Where the pipe narrows (smaller A), the fluid speeds up (larger v). This equation is really just the **principle of conservation of mass** applied to a flowing fluid.

Bernoulli's Equation LO 5.8–5.10

Bernoulli's equation describes how pressure, speed, and height are all related along a streamline for an ideal fluid in horizontal or inclined flow — essentially a statement of energy conservation for moving fluids. A key consequence, known as the **Bernoulli effect**, is that a pressure difference can arise purely from different rates of flow: where a fluid moves faster, its pressure is lower.

This principle has a direct application in **blood physics**: as blood flows through a narrowed (constricted) blood vessel, its speed increases (by the equation of continuity) and its pressure drops (by Bernoulli's effect) — a key concept in understanding conditions like arterial stenosis, which is exactly why MDCAT loves testing this cross-over between physics and physiology.

KEY FORMULAS

Equation of continuity	$A_1v_1 = A_2v_2 = \text{constant}$

Bernoulli's equation (horizontal tube)	$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$
Bernoulli's equation (general form)	$P + \frac{1}{2}\rho v^2 + \rho g h = \text{constant}$

MDCAT Tip: Remember the direction of the Bernoulli effect with one line: "faster flow, lower pressure." This single rule explains airplane lift, a shower curtain being sucked inward, and pressure drops across narrowed blood vessels.

Common Trap: Students often assume laminar (streamline) flow is the "normal" case in real life — but the syllabus explicitly notes that most practical fluid-flow situations are actually turbulent, not laminar. Laminar flow is the simplified, idealized case used for calculations.

60-Second Revision

- Terminal velocity reached when drag force = weight (net force = 0)
- Laminar = smooth, predictable; turbulent = chaotic (most real flows are turbulent)
- Equation of continuity: Av = constant → narrower pipe means faster flow
- Bernoulli's effect: faster flow → lower pressure (applies to blood vessels too)

QUICK CHECK

1. At terminal velocity, the net force acting on a falling object in a fluid is:
   A) Maximum B) Increasing C) Zero D) Equal to drag force only
2. According to the equation of continuity, if a pipe's cross-sectional area decreases, the fluid's speed:
   A) Decreases B) Increases C) Stays the same D) Becomes zero
3. As blood flows through a narrowed artery, according to Bernoulli's effect, blood pressure at the narrowing:
   A) Increases B) Decreases C) Stays constant D) Becomes negative

Answers: 1-C, 2-B, 3-B

END OF UNIT 5 — EXAMOO

6 Waves

How energy travels through a medium — and the rhythmic motion behind it

PMDC Syllabus Unit 6 — Sub-topics: Wave Motion, Progressive Waves, Wave Characteristics, Wave Speed, Transverse/Longitudinal Waves, Speed of Sound (Newton's Formula & Laplace's Correction), Superposition, Interference, Stationary Waves, Organ Pipes, Simple Harmonic Motion, Circular Motion and SHM

Wave Motion & Progressive Waves LO 6.1–6.2

Shake one end of a rope or a spring and watch a disturbance travel along its length — that disturbance is a **wave**. A **progressive (travelling) wave** carries energy away from its source without any bulk transfer of matter. Importantly, **mechanical waves** (like sound or waves on a rope) require a physical medium to travel through, while **electromagnetic waves** (like light) do not — they can travel through the vacuum of space.

Characteristics of a Wave & Wave Speed LO 6.3–6.5

Every wave can be described using a shared vocabulary: the **medium** it travels through, **displacement** of a particle from its rest position, **amplitude** (maximum displacement), **period** (time for one complete cycle), **wavelength** (distance between two consecutive identical points), and **velocity** (how fast the wave pattern moves). In longitudinal waves, we also talk about **compressions** (regions of high density) and **rarefactions** (regions of low density); in transverse waves, we talk about **crests** (peaks) and **troughs** (valleys).

KEY FORMULA

Wave equation	$v = f\lambda$

Transverse vs. Longitudinal Waves LO 6.6

In a **transverse wave**, particles of the medium vibrate perpendicular to the direction the wave travels (a rope shaken up-down, or light waves). In a **longitudinal wave**, particles vibrate parallel to (back and forth along) the direction of travel, creating compressions and rarefactions — sound is the classic example.

Speed of Sound — Newton's Formula & Laplace's Correction LO 6.7–6.9

Newton calculated the speed of sound in air by assuming that as a sound wave passes through, compressions and rarefactions happen at constant temperature (an *isothermal* assumption), applying Boyle's Law to get $v = \sqrt{(P/\rho)}$. Using standard atmospheric pressure and air density, this formula predicts a speed of about **280 m/s** — but the experimentally measured speed of sound in air is about **332 m/s**, a significant mismatch.

Laplace corrected this error by pointing out that compressions and rarefactions actually happen too rapidly for heat to flow away — meaning the process is really *adiabatic*, not isothermal. Using

the adiabatic gas relation (PV^{γ} = constant) instead of Boyle's Law, Laplace derived a corrected formula that matches experiment much more closely.

KEY FORMULAS

Newton's formula (isothermal, incorrect)	**$v = \sqrt{(P/\rho)}$ → predicts ≈280 m/s**
Laplace's corrected formula (adiabatic)	**$v = \sqrt{(\gamma P/\rho)}$ → matches ≈332 m/s (experimental)**
γ (gamma)	**$\gamma = C_p / C_v$ (ratio of molar specific heats)**

MDCAT Tip: Speed of sound in air increases with temperature (faster molecular motion transmits the disturbance quicker) and is affected by humidity and the specific gas the sound travels through — these "factors affecting speed of sound" are a favourite MDCAT one-liner category.

Superposition, Interference & Stationary Waves LO 6.10–6.13

The **principle of superposition** states that when two or more waves overlap at a point, the resultant displacement is simply the algebraic sum of the individual displacements. Applied to sound, two coherent sound waves overlapping produce **interference** — reinforcing each other (louder) at some points and cancelling (quieter or silent) at others.

When two identical waves travel in opposite directions and overlap — for example, a wave and its own reflection — they create a **stationary (standing) wave**, a pattern that appears fixed in place, with points of zero displacement called **nodes** and points of maximum displacement called **antinodes**.

Stationary Waves in Strings & Organ Pipes LO 6.14–6.16

A stretched string fixed at both ends (like a guitar string) can only vibrate in specific patterns called **modes of vibration**, each with its own characteristic frequency. Similarly, **organ pipes** (columns of air, open or closed at the ends) support stationary waves formed by the superposition of the original sound wave and its reflection back down the tube — this is the physical basis of how wind and brass instruments produce specific musical notes.

Simple Harmonic Motion (SHM) LO 6.17

Simple Harmonic Motion is a special, mathematically clean type of oscillation where the restoring force is always directly proportional to displacement from the equilibrium position, and always points back toward it: $F = -kx$. As an oscillating object moves, energy continuously trades between kinetic energy (maximum at the equilibrium/mean position, where speed is greatest) and potential energy (maximum at the extreme positions, where the object momentarily stops) — while the TOTAL energy stays constant.

Circular Motion and SHM LO 6.18

Here's a beautiful connection: if an object moves at constant speed around a circle, and you only look at the "shadow" (projection) of that object on a diameter of the circle, that shadow moves

back and forth exactly as if it were undergoing Simple Harmonic Motion. This is why SHM's acceleration and velocity equations can be derived directly from uniform circular motion mathematics — connecting Units 4 and 6 of this syllabus.

KEY FORMULAS

Restoring force (SHM condition)	**F = -kx**
Total energy in SHM	**E = ½kA² (A = amplitude)**

Common Trap: Maximum speed in SHM occurs at the equilibrium (mean) position — NOT at the extreme ends, where speed is actually zero (that's where acceleration is maximum instead). Students frequently flip this around.

60-Second Revision

- Mechanical waves need a medium; EM waves don't
- Wave equation: v = fλ; transverse (⊥ vibration) vs longitudinal (∥ vibration)
- Newton's formula (isothermal) underestimates sound speed; Laplace's correction (adiabatic, uses γ) fixes it
- Stationary waves = nodes (zero displacement) + antinodes (max displacement)
- SHM: F = -kx; KE max at mean position, PE max at extremes; total energy constant
- Uniform circular motion projected onto a diameter = SHM

QUICK CHECK

1. Newton's formula for the speed of sound in air assumes the process is:
   A) Adiabatic B) Isothermal C) Isobaric D) Isochoric
2. Laplace's correction uses the ratio γ, defined as:
   A) Cv/Cp B) Cp/Cv C) Cp + Cv D) Cp - Cv
3. In SHM, maximum speed occurs at:
   A) The extreme positions B) The mean (equilibrium) position C) Halfway to the extreme D) It's constant throughout

Answers: 1-B, 2-B, 3-B

END OF UNIT 6 — EXAMOO

7 Thermodynamics

Heat, work, and the energy bookkeeping that governs every engine

PMDC Syllabus Unit 7 — Sub-topics: Thermal Equilibrium, Heat, Molar Specific Heat, Work Done by a Thermodynamic System, First Law of Thermodynamics, Relation Cp - Cv = R

Thermal Equilibrium & Heat LO 7.1

When two objects at different temperatures are placed in contact, thermal energy always flows from the region of higher temperature to the region of lower temperature — never the other way on its own. This flow continues until both reach the same temperature, a state called **thermal equilibrium**. **Heat** is precisely this energy in transit due to a temperature difference — it is not something an object "contains," but energy that moves.

Molar Specific Heat of a Gas LO 7.2, 7.6

Since one mole of any substance always contains the same number of molecules, it's often more convenient to define specific heat "per mole" rather than "per kilogram" — this is **molar specific heat**. For gases specifically, we must be careful: heating a gas can cause both temperature AND volume to change, so we define two different molar specific heats depending on which condition is held fixed:

Molar specific heat at constant volume (Cv): heat required to raise the temperature of 1 mole of gas by 1 K while volume is kept fixed (so no work is done — all the heat goes into raising internal energy).

Molar specific heat at constant pressure (Cp): heat required to raise the temperature of 1 mole of gas by 1 K while pressure is kept fixed (here, the gas must also expand and do work, so MORE heat is needed for the same temperature rise).

Work Done by a Thermodynamic System LO 7.3

When a gas expands against an external pressure P, pushing a piston outward through a volume change ΔV, it does work on its surroundings: $W = P\Delta V$. This is the mechanical work a thermodynamic system performs during any volume change, and it is central to understanding how engines convert heat into useful work.

The First Law of Thermodynamics LO 7.4–7.5

The First Law is simply the law of conservation of energy, applied to heat and work: the heat supplied to a system (Q) equals the increase in its internal energy (ΔU) plus the work done BY the system (W). At constant volume, since no work is done (ΔV = 0), all the supplied heat goes directly into raising internal energy: $QV = Cv\,\Delta T = \Delta U$.

> **Definition:** The **First Law of Thermodynamics** is expressed as **Q = ΔU + W**. It tells us that energy supplied as heat to a system can only do two things: increase the system's internal energy, or be used by the system to do external work — nothing is ever created or destroyed in the process.

Deriving Cp - Cv = R LO 7.7

When one mole of an ideal gas is heated at constant pressure instead of constant volume, its internal energy still rises by exactly the same amount for the same temperature change ΔT (since internal energy of an ideal gas depends only on temperature). But now the gas also expands and does extra work, PΔV, against the constant external pressure. Applying the First Law at constant pressure: Cp ΔT = Cv ΔT + PΔV. Using the ideal gas equation for one mole (PV = RT), the work term

simplifies to PΔV = RΔT. Substituting this in and cancelling ΔT throughout gives the elegant final result:

KEY FORMULAS

Work done during volume change	**W = PΔV**
First Law of Thermodynamics	**Q = ΔU + W**
Heat at constant volume	**Qv = Cv ΔT = ΔU**
Heat at constant pressure	**Qp = Cp ΔT**
Relation between Cp and Cv (per mole)	**Cp - Cv = R**

MDCAT Tip: Cp is always greater than Cv, by exactly the universal gas constant R — because raising the temperature at constant pressure requires extra energy to do expansion work, on top of raising internal energy.

Common Trap: Don't confuse "heat" with "internal energy" — heat (Q) and work (W) are energy *in transit* (they only exist during a process), while internal energy (U) is a property the system *has* at any given state. This distinction underlies the entire First Law.

60-Second Revision

- Heat always flows from higher to lower temperature until thermal equilibrium
- Cv = heat per mole per K at constant volume; Cp = heat per mole per K at constant pressure
- First Law: Q = ΔU + W (conservation of energy)
- Cp - Cv = R (derived using PΔV = RΔT for one mole of ideal gas)

QUICK CHECK

1. Heat naturally flows from:
   A) Low to high temperature always B) High to low temperature C) It never flows spontaneously D) Only in solids
2. At constant volume, all the heat supplied to a gas goes into:
   A) Doing external work B) Increasing internal energy C) Increasing pressure only D) Nothing, it is lost
3. The relation Cp - Cv = R holds for:
   A) Any substance B) One mole of an ideal gas C) Liquids only D) Solids only

Answers: 1-B, 2-B, 3-B

END OF UNIT 7 — EXAMOO

8 Electrostatics

Charges at rest — and the invisible fields and potentials they create

PMDC Syllabus Unit 8 — Sub-topics: Coulomb's Law, Electric Field, Electric Field due to a Point Charge, Field Lines, Electric Field due to an Infinite Sheet of Charge, Electric Potential Energy & Potential due to a Point Charge, Charging/Discharging a Capacitor through a Resistance

Coulomb's Law LO 8.1

Rub a balloon on your hair and it sticks to a wall — that's static electricity at work. **Coulomb's Law** states that the electrostatic force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them. Importantly, the syllabus emphasizes that this force is *reduced* when the charges sit in a medium other than free space (like water or oil), because the medium's permittivity is greater than that of free space.

KEY FORMULA

Coulomb's Law (free space)	$F = kq_1q_2/r^2$, where $k = 1/4\pi\varepsilon_0$
Coulomb's Law (in a medium)	$F = q_1q_2/4\pi\varepsilon r^2$ ($\varepsilon > \varepsilon_0$, so F is smaller)

Electric Field LO 8.2–8.4

An **electric field** is a "field of force" — a region of space around a charge where another charge placed there would feel a force. This is the same conceptual idea as a gravitational field around a mass, just for electric charges instead. Electric fields are represented visually using **field lines**: they point away from positive charges and into negative charges, and their density (how close together they are) shows the field's strength at that location.

For two point charges of equal magnitude, the field-line pattern looks very different depending on their signs: with the **same sign** (both positive or both negative), the lines repel and curve away from each other with a "neutral point" between them where the field cancels to zero; with **opposite signs**, the lines flow directly from the positive charge into the negative charge.

Electric Field due to an Infinite Sheet of Charge LO 8.5

For a very large (effectively infinite) charged conducting plate, the electric field lines emerge perpendicular to the surface and are uniformly spaced — meaning the field strength doesn't weaken with distance from the sheet the way a point charge's field does. This is an important idealized case used to model charged plates such as capacitor plates.

Electric Potential Energy & Potential due to a Point Charge LO 8.6–8.8

Electric potential (V) at a point is defined as the work done in bringing a unit positive charge from infinity to that point, without any acceleration. It's essentially "electrical height" — charge naturally tends to flow from high potential to low potential, just as water flows downhill. Electric potential is a scalar quantity, measured in volts (joules per coulomb).

Definition: The electric potential at a distance r from a point charge Q is **V = kQ/r**. Combined with a test charge q, the **electric potential energy** of the pair is U = qV = kQq/r — the energy stored in their configuration due to their mutual electrostatic interaction.

KEY FORMULAS

Electric field due to a point charge	**$E = kQ/r^2$**
Electric potential due to a point charge	**$V = kQ/r$**
Electric potential energy (two point charges)	**$U = kQq/r$**
Unit of potential	**volt (V) = joule/coulomb (J/C)**

Charging & Discharging a Capacitor Through a Resistance LO 8.9

When a capacitor is connected to a battery through a resistor, it doesn't charge up instantly — the resistance limits how fast charge can flow onto the plates, so the charge builds up gradually, quickly at first and then more slowly as the capacitor "fills up" and opposes further charge with its own growing voltage. Discharging through a resistor follows the reverse pattern: charge (and current) starts high and decays gradually toward zero. Both processes follow a smooth exponential curve, characterized by a "time constant" that depends on the resistance and capacitance in the circuit.

MDCAT Tip: A larger resistance or larger capacitance both make charging/discharging take LONGER — more resistance limits current flow, and more capacitance simply needs more charge to reach the same voltage.

Common Trap: Don't confuse electric field (a vector, force per unit charge, $E = kQ/r^2$) with electric potential (a scalar, energy per unit charge, $V = kQ/r$) — notice the field falls off as $1/r^2$, while potential falls off as only $1/r$. MDCAT frequently tests this exact distinction.

60-Second Revision

- Coulomb's Law: $F = kq_1q_2/r^2$; force is reduced in a medium other than free space
- Electric field (vector) points away from + charges, into - charges; $E = kQ/r^2$
- Field near an infinite charged sheet is uniform (doesn't weaken with distance)
- Electric potential (scalar): $V = kQ/r$; potential energy $U = kQq/r$
- Capacitor charging/discharging through a resistor follows a gradual exponential curve, not an instant jump

QUICK CHECK

1. Coulomb's force between two charges placed in a medium (compared to free space) is:
   A) Increased B) Reduced C) Unchanged D) Reversed in direction
2. The electric field near an infinite charged conducting sheet is:
   A) Zero B) Uniform (constant with distance) C) Decreasing as $1/r^2$ D) Decreasing as $1/r$

3. When a capacitor charges through a resistor, the charge on it:
A) Jumps instantly to maximum B) Builds up gradually along an exponential curve C) Stays at zero D) Oscillates continuously

Answers: 1-B, 2-B, 3-B

END OF UNIT 8 — EXAMOO

Units 1–8 Complete!

You've now covered every Physics sub-topic PMDC lists for Units 1–8, straight from your prescribed textbook. Revise the formula boxes, retake every Quick Check, and send over the second Physics textbook so Examoo can build Units 9–16 (Current Electricity through Nuclear Physics) in this exact style. Best of luck!

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Units 9–16

Continuing PMDC's MDCAT 2025 Physics syllabus (Section 3) — sourced from the Second Year Physics textbook

How to use this book: Same format as Units 1–8 — every "LO" tag matches the official PMDC Learning Outcome number, so you can cross-check instantly. Read the concept, lock in the formula box, dodge the trap box, test yourself with the quick-check MCQs. Simply insert these pages after Unit 8 in your first book.

9 Current Electricity

Charges on the move — the physics behind every circuit

PMDC Syllabus Unit 9 — Sub-topics: Steady Current, Ohm's Law, Factors Affecting Resistance & Temperature Coefficient of Resistivity, Internal Resistance of Sources, Maximum Power Output | **Standard physics reference — not found as dedicated content in your uploaded textbook**

Steady Current LO 9.1

An electric current is simply the flow of charge. When that flow is constant — the same amount of charge passing any point in the circuit every second — we call it a **steady (direct) current**. Current is defined as the rate of flow of charge: $I = Q/t$, measured in amperes (A), where 1 ampere means 1 coulomb of charge flows past a point every second.

Ohm's Law LO 9.2

Ohm's Law states that, at constant temperature, the current flowing through a conductor is directly proportional to the potential difference (voltage) applied across it: $V = IR$, where R is the resistance — a constant of proportionality that depends on the conductor's material and dimensions.

Resistance, Resistivity & Temperature Coefficient LO 9.3

A conductor's resistance depends on four factors: it increases with the length of the conductor, decreases with a larger cross-sectional area, and depends on the material itself through a property called **resistivity (ρ)** — a fixed property of the material regardless of its shape. Resistance and resistivity are related by $R = \rho L/A$.

For most conductors, resistivity — and therefore resistance — increases as temperature rises (more thermal vibration means more collisions for moving electrons). This is captured by the **temperature coefficient of resistivity (α)**, which measures the fractional change in resistance per degree rise in temperature.

Internal Resistance of Sources LO 9.4

Every real battery or cell has some **internal resistance (r)** — resistance within the source itself, due to the chemicals and materials inside it. Because of this, the voltage measured across a battery's terminals (terminal voltage) is always a little less than its full EMF (electromotive force) once current is flowing, since some voltage is "used up" driving current through the internal resistance itself.

Definition: If a source has EMF ε and internal resistance r, and delivers current I to an external circuit, the terminal voltage is **V = ε − Ir**. This is why a car battery's voltage appears to "sag" briefly when the starter motor draws a large current.

Maximum Power Output LO 9.5

When a source with internal resistance r delivers power to an external (load) resistance R, the power delivered to the load is maximised when the **load resistance equals the internal resistance** (R = r) — a result known as the maximum power transfer condition. This principle matters in designing efficient electrical and electronic systems, from car audio amplifiers to signal transmission lines.

KEY FORMULAS

Current	**I = Q/t**
Ohm's Law	**V = IR**
Resistance from resistivity	**R = ρL/A**
Terminal voltage (source with internal resistance)	**V = ε - Ir**
Condition for maximum power transfer	**R = r (load = internal resistance)**

MDCAT Tip: When a battery is short-circuited (R ≈ 0), the current is limited only by its internal resistance: I = ε/r. This is exactly why short-circuiting a battery can be dangerous — a very large current flows briefly.

Common Trap: Don't confuse EMF (ε) with terminal voltage (V) — EMF is the maximum possible voltage a source can provide (when no current flows), while terminal voltage is always slightly less once current is actually flowing, due to the internal resistance "eating" some voltage.

60-Second Revision

- Steady current: I = Q/t; Ohm's Law: V = IR
- Resistance R = ρL/A — depends on length, area, and material (resistivity)
- Resistivity increases with temperature for most conductors (temperature coefficient α)
- Terminal voltage V = ε - Ir; max power transfer when load R = internal resistance r

QUICK CHECK

1. Ohm's Law states that at constant temperature, current is directly proportional to:
   A) Resistance B) Potential difference C) Time D) Power
2. The resistance of a conductor increases when:
   A) Length decreases B) Area increases C) Length increases D) Temperature decreases (for most conductors)
3. Maximum power is transferred to a load when:
   A) Load resistance is zero B) Load resistance equals internal resistance C) Load resistance is infinite D) EMF is zero

Answers: 1-B, 2-C, 3-B

END OF UNIT 9 — EXAMOO

10 Electromagnetism

How electric currents create magnetic fields — and push moving charges

PMDC Syllabus Unit 10 — Sub-topics: Magnetic Flux Density/Magnetic Field, Magnetic Flux, Motion of a Charged Particle in a Magnetic Field | **Standard physics reference — not found as dedicated content in your uploaded textbook**

Magnetic Flux Density (Magnetic Field) LO 10.1

A moving charge (an electric current) creates a magnetic field around it — this is the deep link between electricity and magnetism. **Magnetic flux density (B)**, often just called the magnetic field, measures the strength of a magnetic field at a point, and is measured in tesla (T).

Magnetic Flux LO 10.2

Magnetic flux (Φ) measures the total amount of magnetic field passing through a given area — conceptually similar to how electric flux measures electric field lines through a surface. It is calculated as the scalar (dot) product of the magnetic field and the area vector: $\Phi = B \cdot A = BA\cos\theta$, where θ is the angle between the field direction and the direction perpendicular (normal) to the surface.

Definition: Magnetic flux is maximum when the field lines pass straight through the surface (θ = 0°, so Φ = BA) and zero when the field lines run parallel to the surface (θ = 90°, so Φ = 0). The SI unit of magnetic flux is the weber (Wb).

Motion of a Charged Particle in a Magnetic Field LO 10.3–10.4

When a charged particle moves into a magnetic field in a direction **perpendicular** to the field, it experiences a force — the **magnetic (Lorentz) force** — given by $F = qvB$, where q is the charge and v is the particle's speed. Crucially, this force always acts perpendicular to the particle's velocity, which means it never does any work on the particle and never changes its speed — it only changes the particle's direction.

Because the force is always perpendicular to velocity and constant in magnitude, the particle is forced into a **circular path**, with the magnetic force providing exactly the centripetal force needed to keep it moving in that circle.

KEY FORMULAS

Magnetic flux	$\Phi = B \cdot A = BA\cos\theta$
Force on a moving charge (perpendicular to B)	$F = qvB$
Radius of circular path (magnetic force = centripetal force)	$r = mv/qB$

MDCAT Tip: Since the magnetic force on a moving charge is always perpendicular to its velocity, this force can never change the particle's kinetic energy or speed — it only bends its path. This is a favourite conceptual MDCAT one-liner.

Common Trap: Don't confuse the direction rule here — the magnetic force direction is found using F = qv × B (right-hand rule for positive charges, reversed for negative charges), NOT simply "along the field" or "along the velocity." Students often assume the force points in the same direction as B or v, which is incorrect.

60-Second Revision

- Magnetic flux density B measures field strength; magnetic flux $\Phi = BA\cos\theta$
- Magnetic force on a moving charge: F = qvB (perpendicular to velocity)
- This force never changes speed — only direction — forcing the particle into a circular path
- Radius of that circular path: r = mv/qB

QUICK CHECK

1. Magnetic flux is maximum when the angle between the field and the area's normal is:
   A) 0° B) 45° C) 90° D) 180°
2. The magnetic force on a charged particle moving perpendicular to a magnetic field changes the particle's:
   A) Speed only B) Direction only C) Both speed and direction D) Neither
3. The SI unit of magnetic flux is the:
   A) Tesla B) Henry C) Weber D) Farad

Answers: 1-A, 2-B, 3-C

END OF UNIT 10 — EXAMOO

11 Electromagnetic Induction

How a changing magnetic field can generate its own electricity

PMDC Syllabus Unit 11 — Sub-topics: Faraday's Law of Electromagnetic Induction, Lenz's Law, Transformer

Faraday's Law of Electromagnetic Induction LO 11.1

Take two coils placed near each other — a **primary coil** connected to a battery and rheostat, and a **secondary coil** connected to a galvanometer. If the current in the primary coil is changed (say, by adjusting the rheostat), the magnetic flux around it changes too — and since the secondary coil sits within that changing magnetic field, an EMF is induced in it. This phenomenon, where a changing current in one coil induces an EMF in a nearby coil, is called **mutual induction**, and it's a direct demonstration of **Faraday's Law**.

Definition: **Faraday's Law** states that the EMF induced in a coil is proportional to the rate of change of magnetic flux through it: $\varepsilon = -N(\Delta\Phi/\Delta t)$, where N is the number of turns in the coil. The faster the flux changes, the greater the induced EMF.

Lenz's Law LO 11.2

Notice the negative sign in Faraday's Law above — it's not just a mathematical detail, it carries real physical meaning. It tells us that the induced EMF always acts in a direction that **opposes the change** that produced it. In the two-coil setup, if the current in the primary coil increases, the induced EMF in the secondary coil acts to oppose that increase. This opposing behaviour is known as **Lenz's Law**, and it is really just the principle of conservation of energy in action — nature "resists" the change rather than assisting it, since assisting it would create energy from nothing.

Transformer LO 11.3–11.4

The primary-secondary coil setup used to demonstrate mutual induction is, in fact, exactly the working principle behind a **transformer** — a device that uses electromagnetic induction to change (step up or step down) an AC voltage. An alternating current in the primary coil creates a continuously changing magnetic flux, which links to the secondary coil (often via a shared iron core, to concentrate the field) and induces an alternating EMF there.

A **step-up transformer** has more turns in its secondary coil than its primary, increasing voltage; a **step-down transformer** has fewer secondary turns, decreasing voltage. Since power transmitted ($P = VI$) stays essentially the same, transformers allow power companies to transmit electricity at very high voltage (and correspondingly low current) along cables over long distances — this dramatically cuts down resistive (I^2R) power losses in the wires — before stepping the voltage back down to safe levels for homes and buildings.

KEY FORMULAS

Faraday's Law (induced EMF)	$\varepsilon = -N(\Delta\Phi/\Delta t)$
Mutual inductance	$\varepsilon_2 = -M(\Delta I_1/\Delta t)$

Transformer turns-secondary voltage ratio	**Vs/Vp = Ns/Np**
Ideal transformer power conservation	**VpIp = VsIs**

MDCAT Tip: Transmitting electricity at high voltage (and thus low current) is the whole point of using transformers in power grids — since resistive power loss depends on I^2 (not just I), even a small drop in current dramatically cuts wasted energy along transmission lines.

Common Trap: A transformer only works with **alternating** current — a steady DC current in the primary coil produces a constant (non-changing) magnetic flux, and by Faraday's Law, a non-changing flux induces zero EMF in the secondary coil. Transformers simply don't work with pure DC.

60-Second Revision

- Faraday's Law: induced EMF ∝ rate of change of magnetic flux ($\varepsilon = -N\Delta\Phi/\Delta t$)
- Lenz's Law: the negative sign — induced EMF always opposes the change that caused it (conservation of energy)
- Transformer: uses mutual induction between primary/secondary coils to step voltage up or down
- Transformers only work with AC, never with steady DC

QUICK CHECK

1. Faraday's Law states that induced EMF is proportional to:
   A) The magnetic field strength alone B) The rate of change of magnetic flux C) The resistance of the coil D) The area of the coil alone
2. Lenz's Law is fundamentally a consequence of the conservation of:
   A) Charge B) Momentum C) Energy D) Mass
3. A transformer will NOT work if the primary coil is connected to:
   A) Alternating current B) Steady direct current C) High-frequency AC D) Low-frequency AC

Answers: 1-B, 2-C, 3-B

END OF UNIT 11 — EXAMOO

12 Alternating Current

Current that keeps reversing direction — and how circuit elements respond

PMDC Syllabus Unit 12 — Sub-topics: Phase of Alternating Current, AC through Resistor/Capacitor/Inductor, Electromagnetic Waves (EM Spectrum)

Phase of Alternating Current LO 12.1

Unlike direct current (DC), which flows steadily in one direction, **alternating current (AC)** continuously reverses direction, typically following a sine-wave pattern: $I = I_0 \sin(\omega t + \varphi)$, where φ is the **phase angle** — the value of the angle at t = 0, describing where in its cycle the wave "starts."

When two AC quantities (say, current and voltage) reach their maximum and minimum values at the same instants, they are said to be **in phase**. If one lags behind or leads ahead of the other in timing, we describe this using **phase lag** or **phase lead** — critically important when circuits contain capacitors or inductors, since these elements shift the timing between current and voltage.

AC Through a Resistor LO 12.2

In a purely resistive AC circuit, current and voltage rise and fall together — they are always **in phase** with each other, exactly as Ohm's Law would suggest at every instant.

AC Through a Capacitor LO 12.2

A capacitor resists the flow of AC through a property called **capacitive reactance (Xc)**, which — unlike a resistor's resistance — depends on frequency: the higher the frequency, the lower the reactance (a capacitor "passes" high-frequency AC more easily). In a purely capacitive circuit, current **leads** the voltage by 90°.

AC Through an Inductor LO 12.2

An inductor (coil) opposes changes in current through a property called **inductive reactance (XL)**, which increases with frequency (an inductor "blocks" high-frequency AC more strongly). In a purely inductive circuit, current **lags behind** the voltage by 90° — the coil's self-induced EMF continuously resists the current's attempt to change.

KEY FORMULAS

Capacitive reactance	**$X_c = 1/(2\pi fC)$**
Inductive reactance	**$X_L = 2\pi fL$**
Impedance (R, L, C in series)	**$Z = \sqrt{[R^2 + (X_L - X_c)^2]}$**
Phase relationships	**Resistor: in phase | Capacitor: I leads V by 90° | Inductor: I lags V by 90°**

MDCAT Tip: Remember "ELI the ICE man" — in an inductor (L), EMF (E) leads current (I) — "ELI"; in a capacitor (C), current (I) leads EMF (E) — "ICE." This classic mnemonic instantly resolves phase-lag/lead MCQs.

Electromagnetic Waves — The EM Spectrum LO 12.3

Electromagnetic waves are produced by accelerating (oscillating) electric charges, which generate mutually regenerating changing electric and magnetic fields able to propagate even through the vacuum of space — unlike mechanical waves, they need no medium. All electromagnetic waves travel at the same speed in a vacuum, the speed of light ($c \approx 3 \times 10^8$ m/s), but differ enormously in frequency and wavelength. Arranged from lowest to highest frequency (longest to shortest wavelength), the **electromagnetic spectrum** runs: radio waves → microwaves → infrared → visible light → ultraviolet → X-rays → gamma rays.

Definition: Higher-frequency EM waves carry more energy per photon (E = hf) — this is why gamma rays and X-rays are used in medical imaging and cancer treatment, while low-frequency radio waves are safely used for everyday communication.

Common Trap: All EM waves travel at the same speed in vacuum, regardless of frequency — a common misconception is that gamma rays "travel faster" than radio waves. They don't; only their frequency (and hence energy) differs.

60-Second Revision

- AC current: $I = I_0 \sin(\omega t + \varphi)$; phase describes timing relationship between quantities
- Resistor: V and I in phase. Capacitor: I leads V by 90°. Inductor: I lags V by 90° ("ELI the ICE man")
- $X_C = 1/(2\pi fC)$ — decreases with frequency; $X_L = 2\pi fL$ — increases with frequency
- EM spectrum (low to high energy): radio → microwave → infrared → visible → UV → X-ray → gamma

QUICK CHECK

1. In a purely inductive AC circuit, the current:
   A) Leads voltage by 90° B) Lags voltage by 90° C) Is in phase with voltage D) Is always zero
2. Capacitive reactance Xc is related to frequency f as:
   A) Xc increases with f B) Xc decreases with f C) Xc is independent of f D) Xc = f^2
3. Which EM wave has the highest frequency (and highest photon energy)?
   A) Radio waves B) Infrared C) Visible light D) Gamma rays

Answers: 1-B, 2-B, 3-D

END OF UNIT 12 — EXAMOO

13 Electronics

How a single component turns AC into usable DC

PMDC Syllabus Unit 13 — Sub-topics: Rectification, PN Junction

PN Junction LO 13.2

A **PN junction diode** is formed by joining p-type and n-type semiconductor material together. This junction has a one-way property: it allows current to flow easily in one direction but blocks it in the other. When the diode is **forward biased** (positive terminal of the battery connected to the p-side), it offers very low resistance and conducts strongly. When **reverse biased** (connections flipped), the diode offers extremely high resistance and current flow is practically zero.

Rectification LO 13.1

Rectification is the process of converting alternating current (AC) into direct current (DC), and it relies entirely on the diode's one-way conducting property. There are two main types:

Half-wave rectification: uses a single diode. Since the diode only conducts during one half of the AC cycle (when it's forward biased) and blocks the other half, the output is a series of one-directional "pulses," with the negative (or positive) half of each cycle completely cut off.

Full-wave rectification (Bridge circuit): uses four diodes arranged in a bridge configuration. During each half-cycle, a different pair of diodes conducts (while the other pair is reverse biased), so both halves of the AC input contribute to the output — producing a much smoother, more continuous pulsating DC than half-wave rectification.

Definition: In a full-wave bridge rectifier, diodes are arranged so that **one diagonal pair conducts during the positive half-cycle** while the other diagonal pair conducts during the negative half-cycle — the current through the external load is always pushed in the same direction, regardless of which half of the AC cycle is occurring.

KEY CONCEPTS

Forward bias	**Low resistance → diode conducts**
Reverse bias	**Very high resistance → practically no current**
Half-wave rectifier	**1 diode; output = pulses from one half-cycle only**
Full-wave bridge rectifier	**4 diodes; output = pulses from both half-cycles**

MDCAT Tip: A full-wave rectifier is always smoother and more efficient than a half-wave rectifier because it uses BOTH halves of the AC cycle, instead of throwing one half away completely.

Common Trap: A rectifier alone produces "pulsating DC," not smooth, constant DC — it still fluctuates from zero to a peak value repeatedly. Additional filtering (typically using a capacitor) is needed to smooth this into steady DC, a detail students often forget when picturing rectifier output.

60-Second Revision

- PN junction diode: conducts in forward bias, blocks in reverse bias
- Rectification = converting AC to DC, using the diode's one-way property
- Half-wave = 1 diode, uses only one half-cycle; Full-wave (bridge) = 4 diodes, uses both half-cycles
- Rectifier output is pulsating DC, not perfectly smooth DC

QUICK CHECK

1. A PN junction diode conducts current easily when it is:
   A) Reverse biased B) Forward biased C) Unbiased D) Never conducts
2. A full-wave bridge rectifier uses how many diodes?
   A) 1 B) 2 C) 4 D) 6
3. The direct output of a simple rectifier circuit (before filtering) is:
   A) Perfectly smooth DC B) Pulsating DC C) Pure AC D) Zero voltage

Answers: 1-B, 2-C, 3-B

END OF UNIT 13 — EXAMOO

14 Dawn of Modern Physics

The moment light revealed its secret double life

PMDC Syllabus Unit 14 — Sub-topic: Quantum Theory and Radiation (Particle Model of Light — Photons)

Planck's Quantum Theory LO 14.1

By the start of the 20th century, classical physics simply couldn't explain certain experiments involving light and matter. In 1901, **Max Planck** proposed a radical idea: energy is not radiated continuously, but in discrete, indivisible little "packets" called **quanta**. Just as matter is made of discrete particles rather than a continuous substance, Planck suggested that electromagnetic energy is also not infinitely divisible — this earned him the 1918 Nobel Prize in Physics.

The Photon — Light as a Particle LO 14.1

These indivisible bundles of light energy are called **photons**. A beam of light of wavelength λ can be thought of as a stream of photons, each travelling at speed c and carrying a specific energy. This particle model exists alongside the wave model of light — light truly behaves as both, depending on the experiment, an idea known as **wave-particle duality**.

Definition: The energy of a single photon of frequency f is **E = hf**, where h is Planck's constant (6.63×10^{-34} J·s). From Einstein's relativity relation $E = mc^2$, a photon's momentum works out to **$p = E/c = h/\lambda$** — meaning light, despite having no rest mass, still carries momentum.

Photoelectric Effect LO 14.1

The **photoelectric effect** is the emission of electrons from a metal surface when light of a suitable frequency shines on it. This phenomenon simply cannot be explained if light were only a wave (a wave should deposit energy gradually and continuously, regardless of frequency) — but it's explained perfectly if light consists of photons.

Each photon can be absorbed by a single electron in the metal. That electron needs a minimum amount of energy — called the **work function (W_0 or φ)** — just to escape the metal's surface. If the incoming photon's energy exceeds this work function, the excess energy becomes the kinetic energy of the ejected electron; if a photon's energy is below the work function, no electron is emitted at all, no matter how intense (bright) the light is.

KEY FORMULAS

Photon energy	**$E = hf = hc/\lambda$**
Photon momentum	**$p = E/c = h/\lambda$**
Einstein's photoelectric equation	**$hf = W_0 + KE(max)$**
At threshold frequency f_0 ($KE = 0$)	**$W_0 = hf_0$**

MDCAT Tip: Below the threshold frequency f_0, absolutely no photoelectrons are emitted — regardless of how intense the light is. Increasing intensity only increases the NUMBER of photons (and hence photoelectric current), not the energy of each individual photon. Only increasing frequency increases each photon's energy.

Common Trap: Not every emitted electron carries the maximum kinetic energy — some lose energy in collisions on their way out of the metal. Einstein's equation ($hf = W_0 + KEmax$) applies specifically to the electrons that escape with the full surplus energy, not the average electron.

60-Second Revision

- Planck: energy is radiated in discrete packets (quanta), not continuously
- Photon energy: $E = hf$; photon momentum: $p = h/\lambda$
- Photoelectric effect proves the particle nature of light
- Einstein's equation: $hf = W_0 + KE(max)$; below threshold frequency, zero electrons emitted regardless of intensity

QUICK CHECK

1. The energy of a photon is given by:
   A) $E = mc^2$ B) $E = hf$ C) $E = \frac{1}{2}mv^2$ D) $E = qV$

2. Increasing the intensity of light below the threshold frequency causes:

A) More photoelectrons to be emitted B) Photoelectrons with higher KE C) Still no photoelectrons emitted D) The metal to melt

3. The photoelectric effect provides evidence for which nature of light?

A) Purely wave nature B) Particle (photon) nature C) Neither D) Only refractive nature

Answers: 1-B, 2-C, 3-B

END OF UNIT 14 — EXAMOO

15 Atomic Spectra

Every element's unique fingerprint of light

PMDC Syllabus Unit 15 — Sub-topic: Atomic Spectra / Line Spectrum

Discrete Energy Levels LO 15.1

Electrons within an isolated atom (such as hydrogen) cannot have just any amount of energy — they can only exist in specific, **discrete energy levels**. This was a revolutionary idea: rather than a continuous range of possible energies, an atom's electrons are restricted to a fixed "ladder" of allowed energy states.

Emission & Absorption Spectra LO 15.1

When an electron drops from a higher energy level to a lower one, it releases the energy difference as a single photon of a very specific frequency (E = hf). Because only certain energy jumps are allowed, the light given off by excited atoms consists of only certain specific frequencies — appearing as a series of bright, sharp lines when passed through a spectrometer. This is called an **emission spectrum**, discovered by J.J. Balmer in 1885 through his work on hydrogen's spectral lines (the **Balmer series**).

The reverse also happens: when white light (containing all frequencies) passes through a cool gas, the gas's atoms absorb exactly those specific frequencies that match their own allowed electron transitions — removing those exact frequencies from the transmitted light and leaving dark lines in an otherwise continuous spectrum. This is called an **absorption spectrum**.

Definition: A key insight: the dark lines in a given element's absorption spectrum occur at **exactly the same frequencies** as the bright lines in that same element's emission spectrum — both correspond to the identical set of allowed energy-level transitions, just observed in opposite directions (energy released vs. energy absorbed).

KEY FORMULA

Photon energy released/absorbed in a transition	**ΔE = hf = E(high) − E(low)**

MDCAT Tip: Since every element has a completely unique set of allowed energy levels, every element produces its own unique line spectrum — like a fingerprint. This is exactly how astronomers determine what distant stars are made of, purely from analysing their light.

Common Trap: Don't confuse a line spectrum (specific discrete frequencies, from atoms) with a continuous (band) spectrum — a common wrong-option in MDCAT MCQs is describing atomic spectra as "continuous," when the entire point is that only discrete lines appear.

60-Second Revision

- Electrons in an atom occupy discrete (fixed) energy levels, not a continuous range
- Emission spectrum: bright lines, produced when electrons drop to lower energy levels
- Absorption spectrum: dark lines, produced when electrons absorb energy to jump to higher levels
- Emission and absorption lines for the same element occur at exactly the same frequencies

QUICK CHECK

1. An emission line spectrum is produced when electrons:
   A) Absorb energy and jump up B) Drop to a lower energy level, releasing a photon C) Leave the atom entirely D) Remain stationary
2. Dark lines in an absorption spectrum occur at frequencies that are:
   A) Random B) The same as that element's emission lines C) Always higher than emission lines D) Unrelated to energy levels
3. Atomic spectra are best described as:
   A) Continuous B) Line (discrete) spectra C) Random noise D) Always identical for every element

Answers: 1-B, 2-B, 3-B

END OF UNIT 15 — EXAMOO

16 Nuclear Physics

Inside the atom's core — decay, half-life, and medicine

PMDC Syllabus Unit 16 — Sub-topics: Composition of Atomic Nuclei, Spontaneous & Random Nuclear Decay, Half-Life & Rate of Decay, Biological and Medical Uses of Radiation

Composition of Atomic Nuclei LO 16.1

Every atom consists of a tiny, dense central **nucleus** containing **protons** (positively charged) and **neutrons** (neutral) — collectively called **nucleons** — surrounded by **electrons** (negatively charged) occupying the much larger space around the nucleus. The number of protons defines the element (atomic number Z), while the total number of protons plus neutrons gives the mass number (A).

Spontaneous & Random Nuclear Decay LO 16.2

Some atomic nuclei are unstable and will eventually break down, releasing radiation — a process called **radioactive decay**. This decay is both **spontaneous** (it happens on its own, without any external trigger like heat or pressure) and **random** (there is no way to predict exactly when any one particular nucleus will decay — only the probability that decay will occur within a given time). This randomness shows up experimentally as natural fluctuations in the measured count rate of a radioactive sample.

Half-Life & Rate of Decay LO 16.3

Even though individual nuclear decays are random and unpredictable, a large collection of radioactive nuclei decays in a very predictable, exponential pattern overall. The **decay constant (λ)** represents the fraction of nuclei that decay per unit time, and the **half-life (T½)** is the time taken for exactly half of a radioactive sample's nuclei to decay — a constant, unchanging value for any given isotope, no matter how much of the sample remains.

Definition: The relationship between decay constant and half-life is **$\lambda = 0.693/T_{½}$**. Notice that a large decay constant λ means a SHORT half-life (the isotope decays quickly), while a small λ means a LONG half-life.

KEY FORMULAS

Decay law (activity/number remaining)	**$A = -\lambda N$ (rate of decay ∝ number of nuclei present)**
Decay constant — half-life relation	**$\lambda = 0.693/T_{½}$**
Mass defect & binding energy	**$E = \Delta mc^2$**

MDCAT Tip: After exactly one half-life, 50% of the original sample remains; after two half-lives, 25% remains; after three, 12.5% — the amount remaining keeps halving, it never reaches exactly zero. This exponential decay pattern is a favourite MDCAT numerical.

Biological and Medical Uses of Radiation LO 16.4

Radioactive isotopes have major applications in medicine. **Radioactive tracers** — small amounts of a radioactive substance introduced into the body (often injected into a vein) — allow doctors to follow the path of chemicals or blood flow through the body, since the emitted radiation can be detected externally (for example, by a rotating **gamma camera**) to build a picture of organ function without invasive surgery.

Radiotherapy uses high-energy radiation (such as gamma rays) in a targeted way to kill or shrink cancerous tumour cells, exploiting the fact that rapidly dividing cancer cells are generally more sensitive to radiation damage than most healthy surrounding cells.

Common Trap: Radioactive decay being "random" does NOT mean it's "unpredictable" at the level of a large sample — while you cannot predict when any single nucleus will decay, the overall decay rate of a large sample follows a precise, predictable exponential law. Random at the individual level, predictable at the statistical level.

60-Second Revision

- Nucleus = protons + neutrons (nucleons); electrons orbit outside the nucleus
- Radioactive decay is spontaneous AND random at the individual nucleus level
- Half-life T½: time for half a sample to decay; $\lambda = 0.693/T_{½}$
- Medical uses: radioactive tracers (diagnosis, gamma camera) and radiotherapy (cancer treatment)

QUICK CHECK

1. Radioactive decay is best described as:
   A) Predictable and triggered externally B) Spontaneous and random C) Only spontaneous, never random D) Controlled by temperature
2. If the half-life of an isotope is 4 hours, after 8 hours the fraction of the original sample remaining is:
   A) 1/2 B) 1/4 C) 1/8 D) 0
3. A radioactive tracer used in medical diagnosis is typically detected using a:
   A) Voltmeter B) Gamma camera C) Ammeter D) Barometer

Answers: 1-B, 2-B, 3-B

END OF UNIT 16 — EXAMOO

All 16 Units Complete!

You now have every Physics unit PMDC lists for MDCAT, Units 1–16, sourced directly from your two prescribed textbooks wherever that content exists — with Units 9 & 10 clearly flagged as standard-physics supplements since your Second Year book doesn't cover them as dedicated topics. Simply insert these pages after Unit 8 in your first book to complete the set. Revise the formula boxes, retake every Quick Check, and go conquer that Physics section. Best of luck!

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MDCAT TEST PREPARATION

ENGLISH

Revision Guide — Strictly Mapped to the Official PMDC MDCAT 2025 Syllabus (English Section)

Every topic taken directly from PMDC's official MDCAT English curriculum

Explained in simple, exam-friendly language — like a teacher explaining to a 15-year-old

Key-fact boxes , examples , MDCAT tips , common traps & quick-check MCQs

Covers all 3 English competency themes — 9 MCQs (5% weightage) of the MDCAT paper

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Contents

Built theme-by-theme from PMDC's MDCAT 2025 English syllabus (Section 4)

How to use this book: Read each concept in plain language, check the examples, lock in the key-facts box, dodge the trap box, note the MDCAT tip, and test yourself with the Quick Check MCQs at the end of every theme. This guide covers only topics listed in PMDC's official MDCAT 2025 English curriculum — nothing extra, nothing skipped.

1 Reading & Thinking Skills

Reading closely, reading between the lines, and reading with feeling

PMDC Syllabus Theme 1 — Sub-topics: Scanning to Answer Questions, Deducing Meaning from Context, Figurative Language

Scanning — reading fast, with a purpose

Scanning means running your eyes quickly over a passage to locate a specific piece of information — a name, date, number, or short fact — WITHOUT reading every single word. This is different from reading for deep understanding. In the MDCAT English section, short passages are often followed by direct questions; the fastest way to answer them is to first look at the question, identify the key word you need to find (e.g., a proper noun or number), and then scan the passage specifically for that word or a close synonym of it.

MDCAT Tip

Read the question BEFORE the passage. Then scan for keywords from the question rather than reading the whole passage word-by-word — this saves precious time in the exam.

Deducing meaning from context

You won't know every word in a passage — but you can often work out its meaning using contextual clues: the sentences before and after it, an example given nearby, a contrast word (like 'however' or 'but'), or a word that restates the same idea in simpler terms. This skill lets you understand unfamiliar vocabulary without needing a dictionary.

Example

'The professor's lecture was so verbose that most students lost interest halfway through.' Even without knowing 'verbose', the context (students losing interest) suggests it means something like 'excessively wordy'.

Figurative language — how writers appeal to the senses

Writers and poets often use figurative language — language that goes beyond its literal meaning — to create vivid images and emotional effects. This includes simile (comparing two things using 'like' or 'as'), metaphor (directly calling one thing another), personification (giving human qualities to non-human things), and imagery (descriptive language that appeals to sight, sound, touch, taste, or smell). Recognising these devices helps you understand not just WHAT a writer says, but HOW they make the reader feel it.

Key Facts

Simile	Compares using 'like' or 'as' (e.g., 'brave as a lion')
Metaphor	Directly states one thing IS another (e.g., 'time is a thief')
Personification	Gives human traits to non-human things (e.g., 'the wind whispered')
Imagery	Descriptive language appealing to the five senses

60-Second Revision

- Scanning = fast reading to locate a specific fact — read the question first, then hunt for keywords
- Contextual clues (surrounding words, examples, contrast words) help you deduce unfamiliar word meanings
- Figurative language (simile, metaphor, personification, imagery) creates sensory and emotional effect

Quick Check

1. Scanning a passage means: A) Reading every word carefully B) Quickly searching for specific information C) Memorising the whole text D) Translating the passage
2. 'The city never sleeps' is an example of: A) Simile B) Personification C) Onomatopoeia D) A direct statement of fact
3. Deducing a word's meaning from surrounding sentences relies on: A) A dictionary B) Contextual clues C) Guessing randomly D) The title only

Answers: 1-B, 2-B, 3-B

2 Formal & Lexical Aspect of Language

The vocabulary and grammar rules that make English precise

PMDC Syllabus Theme 2 — Sub-topics: Contextual Vocabulary & Synonyms, Pronoun-Antecedent Agreement, Tenses, Infinitives & Gerunds, Adverbs, Prepositions, Transitional Devices, Punctuation, Sentence Classes & Phrases, Sentence Types, Active/Passive Voice, Direct/Indirect Speech

Vocabulary from context & shades of meaning

Beyond simply finding a word's meaning, strong readers also notice shades of meaning between near-synonyms — words that mean almost the same thing but carry a different tone. This is especially important for spotting irony (saying the opposite of what is meant), parody (a humorous, exaggerated imitation of a style), and satire (using humour or exaggeration to criticise something).

Example

'Slim' and 'skinny' are both synonyms for 'thin', but 'slim' sounds like a compliment while 'skinny' can sound critical — same core meaning, different shade/tone.

Pronoun-antecedent agreement & tenses

A pronoun must agree with its antecedent (the noun it refers to) in number (singular/plural) and gender. For example, 'Each student must submit HIS OR HER assignment' (singular antecedent 'each student' needs a singular pronoun), not 'their'. Tenses show WHEN an action happens — past, present, or future — and each has simple, continuous, perfect, and perfect continuous forms. Using the correct, consistent tense throughout a piece of writing is essential for clarity.

Example

Incorrect: 'Every player must bring their own kit.' (mismatched number) → Correct: 'Every player must bring his or her own kit.'

Infinitives, gerunds & adverbs

An infinitive is the base form of a verb usually preceded by 'to' (e.g., 'to run', 'to learn') and can function as a noun, adjective, or adverb in a sentence (e.g., 'To succeed requires effort' — infinitive phrase as the subject). A gerund is the '-ing' form of a verb used as a noun (e.g., 'Swimming is good exercise' — 'swimming' acts as a noun, the subject of the sentence). An adverb modifies a verb, adjective, or another adverb, and its position in a sentence can change depending on its kind (e.g., adverbs of manner, time, place, frequency, or degree) and how much emphasis is needed.

Key Facts

Infinitive	'to' + base verb; can act as noun/adjective/adverb (e.g., 'to write')
Gerund	Verb + '-ing' used as a noun (e.g., 'writing')
Adverb position	Varies by type — manner/place usually after the verb; frequency often before the main verb

Prepositions & transitional devices

A preposition shows the relationship between a noun/pronoun and another word in the sentence — indicating position ('under', 'between'), time ('before', 'during'), movement ('into', 'through'), or direction ('toward', 'across'). Transitional devices (like 'however', 'therefore', 'in addition', 'consequently') are connecting words or phrases used in speech and writing to link ideas smoothly, showing relationships such as contrast, cause-effect, addition, or sequence.

Example

'She studied hard; therefore, she passed the exam with distinction.' — 'therefore' signals a cause-and-effect transition.

Punctuation — the traffic signals of writing

Correct punctuation (commas, full stops, semicolons, colons, apostrophes, quotation marks, question marks, etc.) is essential for clarity — the same words can carry completely different meanings depending on how they're punctuated. Each punctuation mark has specific rules for where and how it should be used.

Sentence classes, phrases & sentence types for various purposes

Sentences are classified by structure (simple, compound, complex, compound-complex) and by function/purpose (declarative — makes a statement; interrogative — asks a question; imperative — gives a command; exclamatory — expresses strong emotion). A phrase (like a noun phrase, verb phrase, or prepositional phrase) is a group of related words without a full subject-verb combination; where a phrase is placed in a sentence can shift emphasis or even change the intended meaning, so recognising and correctly positioning them matters for both clarity and effective communication.

Active/passive voice & direct/indirect speech

In the active voice, the subject performs the action ('The teacher explained the lesson'); in the passive voice, the subject receives the action ('The lesson was explained by the teacher'). Choosing between them depends on what you want to emphasise — the doer or the action/receiver. Direct speech reports someone's exact words in quotation marks ('She said, "I am tired."'), while indirect (reported) speech conveys the same meaning without quoting exactly, often requiring changes in tense, pronouns, and time/place words ('She said that she was tired.').

Key Facts

Active voice	Subject DOES the action (e.g., 'The cat chased the mouse')
Passive voice	Subject RECEIVES the action (e.g., 'The mouse was chased by the cat')
Direct speech	Exact words in quotation marks
Indirect speech	Reported meaning — tense/pronouns often shift back

Common Trap

When converting direct to indirect speech, remember to shift the tense backward (present → past) and change pronouns/time-place words appropriately — forgetting this is the most common MDCAT English error.

60-Second Revision

- Shades of meaning between synonyms reveal irony, parody, and satire
- Pronouns must agree with their antecedent in number and gender; tenses must stay consistent
- Infinitive = 'to' + verb; Gerund = verb + '-ing' used as a noun; adverb position depends on its kind
- Prepositions show position/time/movement/direction; transitional devices link ideas smoothly
- Punctuation changes meaning; sentences are classified by structure and by purpose
- Active voice emphasises the doer; passive voice emphasises the receiver of the action
- Direct speech quotes exact words; indirect speech reports meaning with tense/pronoun shifts

Quick Check

1. 'Each of the girls must bring HER book' shows correct: A) Verb tense B) Pronoun-antecedent agreement C) Preposition use D) Punctuation
2. 'Swimming is my favourite hobby' — 'Swimming' here is a: A) Infinitive B) Gerund C) Preposition D) Adverb

3. Which sentence is in the passive voice? A) 'The chef cooked the meal' B) 'The meal was cooked by the chef' C) 'The chef is cooking' D) 'Cook the meal'
4. Converting 'He said, "I am happy."' to indirect speech gives: A) He said that he is happy B) He said that he was happy C) He said I am happy D) He says he was happy

Answers: 1-B, 2-B, 3-B, 4-B

3 Writing Skills

Catching and correcting the errors that weaken good writing

PMDC Syllabus Theme 3 — Sub-topics: Proofreading & Editing, Faulty Sentence Structure, Subject-Verb Agreement, Errors of Function & Spelling

Proofreading and editing

Proofreading means carefully re-reading a piece of writing (your own or someone else's) specifically to catch errors of usage and style — grammar mistakes, awkward phrasing, repeated words, and inconsistent tone — before it is considered finished. Editing goes a step further, improving clarity, flow, and word choice, not just fixing outright errors. A systematic approach — checking grammar, then spelling, then punctuation, then style, one pass at a time — catches far more errors than a single read-through.

Faulty sentence structure

A sentence has faulty structure when its grammar breaks down — common problems include sentence fragments (an incomplete sentence missing a subject or verb, punctuated as if complete), run-on sentences (two or more complete sentences incorrectly joined without proper punctuation or a conjunction), and misplaced or dangling modifiers (a descriptive word/phrase positioned so that it appears to describe the wrong thing).

Example

Fragment: 'Because she was late.' (incomplete thought) → Corrected: 'She missed the bus because she was late.'
Run-on: 'It was raining we stayed inside.' → Corrected: 'It was raining, so we stayed inside.'

Subject-verb agreement

The verb in a sentence must agree with its subject in number: a singular subject takes a singular verb, and a plural subject takes a plural verb. This can get tricky when other words come between the subject and verb, or when the subject is a collective noun, a compound subject joined by 'and'/'or', or an indefinite pronoun like 'everyone' or 'each' (which is treated as singular).

Example

Incorrect: 'The list of items ARE on the table.' → Correct: 'The list of items IS on the table.' (subject is 'list', singular — 'of items' is just a describing phrase, not the subject)

Errors of function words and spelling

Function words (articles like 'a/an/the', conjunctions, prepositions, and auxiliary verbs) are small but crucial — using the wrong one can distort meaning or sound clearly incorrect, even when content words are all correct. Similarly, spelling errors (including commonly confused word pairs like 'their/there/they're' or 'affect/effect') undermine the clarity and professionalism of writing, even when grammar is otherwise correct.

Common Trap

Don't confuse 'its' (possessive — belonging to it) with 'it's' (a contraction of 'it is'). This is one of the most commonly tested spelling/function-word errors on MDCAT.

60-Second Revision

- Proofreading catches errors; editing improves clarity, flow, and style beyond just fixing mistakes
- Avoid sentence fragments, run-on sentences, and misplaced/dangling modifiers
- Verb must agree in number with its true subject — watch out for words that come between them

• Function-word and spelling errors (their/there/they're, its/it's) distort meaning even with correct grammar elsewhere

Quick Check

1. 'Because it was raining.' as a standalone sentence is an example of: A) A complete sentence B) A sentence fragment C) A run-on sentence D) Correct punctuation
2. 'Each of the students HAS submitted their assignment' shows correct subject-verb agreement because: A) 'students' is plural so needs a plural verb B) 'each' is singular and takes a singular verb C) The sentence has no subject D) 'assignment' is the subject
3. Which is used correctly? A) 'The dog wagged it's tail' B) 'The dog wagged its tail' C) 'The dog wagged its' tail D) 'The dog wagged it is tail'

Answers: 1-B, 2-B, 3-B

All 3 Themes Complete!

You've now revised every English competency-theme that PMDC lists (5% weightage, 9 MCQs) of the MDCAT paper. Go back through each Key Facts box, retake every Quick Check, and keep a close eye on the Common Traps — small, easy marks that are simple to secure once you know exactly what to look for. Best of luck on your MDCAT journey!

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MDCAT TEST PREPARATION

LOGICAL REASONING

Revision Guide — Strictly Mapped to the Official PMDC MDCAT Syllabus

Every topic taken directly from PMDC's official MDCAT curriculum
Original worked examples, step-by-step strategies, and shortcuts
Formula boxes, tips, common traps & quick-check MCQs

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Contents

Built unit-by-unit from PMDC's MDCAT 2025 Logical Reasoning syllabus (Section 5)

How to use this book: Each unit follows the exact sub-topics listed in PMDC's official MDCAT curriculum document — nothing extra, nothing skipped. Every "LO" tag refers to the matching Learning Outcome number in the official syllabus. Every example in this book is original — read the strategy, study the worked example, avoid the trap box, then test yourself with the quick-check MCQs.

Scope note: PMDC's Logical Reasoning syllabus has exactly 6 themes, and this book covers all 6 in full. No extra topics (like verbal analogies, coding-decoding, or seating-arrangement puzzles) are included unless PMDC's own syllabus document explicitly lists them — this keeps your revision tightly focused on exactly what MDCAT can legally test.

1 Critical Thinking

Separating what MUST be true from what merely sounds true

PMDC Syllabus Theme 5.1 — "The process of evaluation which uses logic to separate truth from falsehood, reasonable from unreasonable beliefs." Sub-skills: Statement & Conclusion, Statement & Assumption, Statement & Inference, Statement & Argument

The Golden Rule of Critical Thinking LO 5.1.1–5.1.3

Every critical thinking question gives you a short statement and asks you to judge something built on top of it — a conclusion, an assumption, an inference, or an argument. The single most important rule across ALL four sub-skills is this: **judge using ONLY the information given, never your own outside knowledge, opinions, or what "usually" happens in real life.** A statement might even describe something scientifically false — your job is to reason from it exactly as written, not to correct it.

Statement and Conclusion

A **conclusion** is a fact that follows with certainty from the statement — nothing more, nothing less. It must be a direct, guaranteed consequence, not just something "probably" true.

Worked Example: *Statement*: "Due to heavy rainfall, the river's water level has risen above the danger mark, and the district administration has ordered evacuation of low-lying villages."
Conclusion I: "Low-lying villages are at risk of flooding." → **Follows** (directly supported — that's exactly why evacuation was ordered).
Conclusion II: "The rainfall was caused by climate change." → **Does not follow** (this is outside information never stated).

Statement and Assumption

An **assumption** is something the speaker takes for granted but never actually says — an unstated belief that MUST be true for the statement to make sense at all. Ask yourself: "If this assumption were false, would the statement fall apart?"

Worked Example: *Statement*: "The school has installed CCTV cameras in every classroom to improve student discipline."
Assumption I: "Cameras can influence how students behave." → **Valid assumption** (the whole plan only makes sense if this is true).
Assumption II: "All students currently misbehave in class." → **Not a valid assumption** (the statement never implies ALL students misbehave — just that discipline can be improved).

Statement and Inference

An **inference** is a reasonable judgment drawn by "reading between the lines" — slightly less direct than a conclusion, but still firmly grounded in the statement, not in outside speculation.

Worked Example: *Statement*: "Sales of the new smartphone model dropped by 40% in the second month after a rival company launched a cheaper alternative with similar features." *Inference*: "Price and features influence customers' buying decisions." → **Reasonable inference** (the drop lines up directly with the rival's cheaper, similar product).

Statement and Argument

Here you're given a yes/no question along with two arguments (one "for," one "against"), and must judge whether each argument is **strong** (relevant, factual, and addresses the real heart of the issue) or **weak** (irrelevant, based on a minor point, or purely emotional).

Worked Example: *Question*: "Should mobile phones be banned in school classrooms?"
Argument I: "Yes, because phones distract students from lessons and enable cheating during tests." → **Strong** (directly relevant, addresses real consequences).
Argument II: "No, because phones are expensive and students should take care of expensive things." → **Weak** (irrelevant to whether they belong in a classroom).

STRATEGY CHECKLIST

Conclusion	**Must follow with certainty — a direct, guaranteed fact**
Assumption	**Unstated, but necessary for the statement to make sense**
Inference	**A reasonable "read between the lines" judgment**
Argument	**Strong = relevant & substantial; Weak = irrelevant or trivial**

MDCAT Tip: If you find yourself thinking "well, in real life this is usually true..." — stop. That's outside knowledge creeping in. Re-read the statement and ask only: "Does THIS text support it?"

Common Trap: Confusing a "possible" outcome with a "certain" one. A conclusion that is merely likely or plausible (but not guaranteed by the statement) does NOT follow — MDCAT examiners deliberately include tempting-but-not-certain options.

60-Second Revision

- Always reason ONLY from the given statement — never outside knowledge or opinion
- Conclusion = certain fact; Assumption = unstated necessary belief; Inference = reasonable reading between the lines
- Argument = judge relevance and strength, not whether you personally agree

QUICK CHECK

1. Statement: "The hospital has extended its visiting hours after patients complained they couldn't meet family after work." Which conclusion follows?

A) All patients were unhappy with the hospital B) The previous visiting hours conflicted with typical work schedules C) The hospital is understaffed D) Family visits improve recovery

2. Statement: "The company now requires all new employees to complete a two-week training program before starting work." What is the underlying assumption?

A) All employees dislike training B) Training can prepare new employees for the job C) The company is losing money D) Two weeks is too short

3. Question: "Should street food vendors be required to obtain a hygiene certificate?" Which argument is STRONG?

A) Yes, because certified vendors are less likely to serve contaminated food and spread illness B) No, because getting a certificate takes time to arrange C) Yes, because certificates look official D) No, because vendors don't like paperwork

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Answers: 1-B, 2-B, 3-A

END OF UNIT 1 — EXAMOO

2 Letters and Symbols Series

Spotting the hidden rule that connects one term to the next

PMDC Syllabus Theme 5.2 — "Sequential order of letters, numbers, or both, arranged so each term is obtained according to some specific rule." Sub-skills: Arithmetical Operations, Geometrical Progression, Series/Sequential Orders (Letters & Symbols)

Number Series — Arithmetic Patterns LO 5.2.1

The most common number series are built by applying the same **arithmetic operation** repeatedly — adding, subtracting, or a combination. Your first move should always be to find the difference between consecutive terms.

Worked Example: Find the missing term: **5, 11, 17, 23, ?**
Differences: 11-5=6, 17-11=6, 23-17=6 → constant difference of +6.
Missing term = 23 + 6 = **29**.

Sometimes the difference itself changes in a pattern — this is called a **geometrical progression** pattern when the ratio (not the difference) stays constant, or an "increasing difference" pattern when the gap itself grows by a rule.

Worked Example (geometric): Find the missing term: **3, 6, 12, 24, ?**
Each term is multiplied by 2 (ratio = 2 throughout) → missing term = 24 × 2 = **48**.

Worked Example (increasing difference): Find the missing term: **2, 3, 5, 8, 12, ?**
Differences: +1, +2, +3, +4, so next difference = +5 → missing term = 12 + 5 = **17**.

Alphabet Series LO 5.2.3

The trick to alphabet series is converting each letter to its position number (A=1, B=2, C=3 … Z=26), spotting the numeric pattern, then converting back to letters.

Worked Example: Find the missing letter: **B, E, H, K, ?**
Positions: B=2, E=5, H=8, K=11 → pattern is +3 each time.
Next position = 11 + 3 = 14 → letter = **N**.

Alpha-Numeric Series LO 5.2.3

These combine letters and numbers in one sequence, often as pairs or groups. Track the letters and numbers as two SEPARATE, interleaved patterns.

Worked Example: Find the missing term: **A2, C4, E6, G8, ?**
Letters (every other letter): A, C, E, G → skip one letter each time → next letter = I.
Numbers: 2, 4, 6, 8 → +2 each time → next number = 10.
Missing term = **I10**.

Symbol Series LO 5.2.3

Symbol series test the same pattern-recognition skill, just using shapes or repeated characters instead of numbers. Look for how many times a shape repeats, rotates, or grows from one term to the next.

Worked Example: Find the next term: ★, ★★, ★★★, ★★★★, ?
Each term adds one more star than the last → next term = ★★★★★ (5 stars).

STRATEGY CHECKLIST

Step 1	**Find the difference (or ratio) between consecutive terms**
Step 2	**Check if that difference itself follows a pattern**
Step 3	**For letters, convert to numbers (A=1…Z=26) first**
Step 4	**For alpha-numeric/symbol series, split into separate mini-patterns**

MDCAT Tip: If a simple constant addition/subtraction doesn't fit, immediately test: (a) multiplication/division (geometric), (b) alternating two interleaved series, and (c) squares or cubes (1, 4, 9, 16… or 1, 8, 27, 64…) — these three cover the vast majority of "trick" series.

Common Trap: Don't stop checking after finding a pattern that fits just the first two terms — always verify your rule against EVERY term in the sequence before locking in your answer. A pattern that works for two terms can still be a coincidence.

60-Second Revision

- Number series: check constant difference, then constant ratio, then a changing-difference pattern
- Alphabet series: convert letters to numbers (A=1…Z=26) to reveal the pattern
- Alpha-numeric/symbol series: split into separate interleaved patterns and solve each independently
- Always verify your rule against every given term, not just the first two

QUICK CHECK

1. Find the missing term: 4, 9, 19, 39, ?
   A) 59 B) 69 C) 79 D) 89
2. Find the missing letter: C, F, I, L, ?
   A) M B) N C) O D) P
3. Find the missing term: B3, D6, F9, H12, ?
   A) I15 B) J14 C) J15 D) K15

Answers: 1-C (pattern ×2+1), 2-C, 3-C

END OF UNIT 2 — EXAMOO

3 Logical Deductions

Turning scattered clues into one organized, certain structure

PMDC Syllabus Theme 5.3 — "Statements and relations between statements are used precisely to make conclusions implied by the statements and relations." Sub-skills: Predicting New Relations, Developing New Structures from Given Information

The Grid Method LO 5.3.1–5.3.2

Logical deduction puzzles give you a set of people, items, or attributes and a handful of clues linking them — your job is to work out the complete, unique arrangement. The single best strategy is to build a **grid (table)**: list every entity down one side and every possible attribute across the top, then use each clue to mark a definite **YES**, a definite **NO**, or leave it blank if still unknown. Once a row or column has only one blank left, that blank must be a YES — this is how you crack the rest of the puzzle purely through elimination.

Worked Example: Three friends — Amina, Bilal, and Sara — each play exactly one sport: Tennis, Badminton, or Swimming.
Clue 1: Amina does not play Tennis or Swimming.
Clue 2: Bilal does not play Badminton.
Step 1: From Clue 1, Amina must play Badminton (the only option left for her).
Step 2: Since Amina has Badminton, and Clue 2 says Bilal doesn't play Badminton anyway, Bilal must play either Tennis or Swimming.
Step 3: Since Badminton is taken by Amina, and no clue restricts Sara further, we need one more clue to fully separate Bilal and Sara between Tennis and Swimming — this shows why deduction puzzles always give you just enough clues to reach exactly ONE valid arrangement, no more and no less.

Predicting New Relations LO 5.3.1

Some questions ask you to combine two or more given relationships to work out a brand-new one that wasn't stated directly — this is the heart of "predicting new relations."

Worked Example: In a class ranking: Hassan scored higher than Zara. Zara scored higher than Imran. Imran scored higher than Bilal.
Question: Who scored the lowest?
Reasoning: Chain the relations in order: Hassan > Zara > Imran > Bilal.
Answer: **Bilal** scored the lowest — a new relation (Hassan > Bilal, and Bilal is last) that wasn't stated directly but is fully deducible.

Developing New Structures LO 5.3.2

More advanced questions give you several overlapping clues about a group (for example, which people share which skills) and ask you to identify who fits a very specific combination — this requires carefully cross-referencing every clue against your grid, not just the most obvious one.

Worked Example: Four students — W, X, Y, Z — each study exactly two subjects from {Biology, Chemistry, Physics}. W and X study Biology and Chemistry. X and Y study Chemistry and Physics. Y and Z study Physics and Biology.
Question: Who studies both Chemistry and Physics?
Reasoning: Scan each student's pair — W: Biology+Chemistry. X: appears in both "Biology+Chemistry" (with W) and "Chemistry+Physics" (with Y) — so X studies Chemistry and Physics.
Answer: **X**.

STRATEGY CHECKLIST

Step 1	**List every entity and every possible attribute in a grid**
Step 2	**Mark definite YES/NO for each clue given**
Step 3	**Use elimination — if only one blank remains in a row/column, it must be YES**
Step 4	**Chain simple relations (rankings, comparisons) in a single ordered line**

MDCAT Tip: Always re-read EVERY clue again after filling in new information — an early clue that seemed unusable often becomes the key to a final deduction once other entities are ruled out.

Common Trap: Never assume a relationship that "seems likely" — only mark something as certain if a clue (or a chain of clues) actually forces that conclusion. Deduction puzzles are designed so guessing leads to wrong answers, while systematic elimination always leads to the one correct arrangement.

60-Second Revision

- Build a grid: entities down one side, attributes across the top
- Mark YES/NO from each clue; use elimination when only one option remains
- For rankings/comparisons, chain them into a single ordered line
- Never guess — only conclude what the clues actually force

QUICK CHECK

1. Four runners finish a race: Ali finishes before Noor. Noor finishes before Hina. Hina finishes before Kamal. Who finishes first?
   A) Noor B) Hina C) Ali D) Kamal

2. Three houses are painted Red, Blue, or Green. House 1 is not Red or Green. House 2 is not Blue. What colour is House 1?
   A) Red B) Blue C) Green D) Cannot be determined
3. In a deduction puzzle, if a row in your grid has only one blank cell left after marking all known NOs, that blank must be:
   A) Left blank permanently B) Marked YES C) Marked NO D) Ignored

Answers: 1-C, 2-B, 3-B

END OF UNIT 3 — EXAMOO

4 Logical Problems

Categorical syllogisms — "All," "Some," and "No" put to the test

PMDC Syllabus Theme 5.4 — "Puzzles which require people to use deductive reasoning skills, meaning they need to look at different pieces of information in order to arrive at an answer." Sub-skills: Inferring Results, Puzzle-Solving Skills

The Four Statement Types LO 5.4.1–5.4.2

MDCAT's classic "logical problems" are **categorical syllogisms**: you're given two or more statements about groups, followed by suggested conclusions, and must judge which conclusions are **necessarily true** based purely on the statements. There are four statement types to know:

THE FOUR STATEMENT TYPES

"All A are B"	**Every member of A is inside B (A is fully contained in B)**
"No A is B"	**A and B have zero overlap — completely separate groups**
"Some A are B"	**At least one member is shared between A and B (could even be all)**
"Some A are not B"	**At least one member of A is definitely outside B**

Chaining Statements Together LO 5.4.1

The real skill is combining two statements to see what MUST follow. A few reliable combination rules:

Valid Combination Rules:
"All A are B" + "All B are C" → **"All A are C" follows**
"All A are B" + "No B is C" → **"No A is C" follows**
"Some A are B" + "All B are C" → **"Some A are C" follows**
"All A are B" + "Some B are C" → **Nothing certain follows about A and C** (the "some" C's might not be the same B's that overlap with A)

Worked Example 1: *Statements*: All doctors are graduates. All graduates are literate.
Conclusion: All doctors are literate.
Verdict: **Follows** (classic "All-All" chain).

Worked Example 2: *Statements*: Some engineers are teachers. All teachers are readers.
Conclusion: Some engineers are readers.
Verdict: **Follows** ("Some-All" chain — the engineers who are teachers are definitely also readers).

Worked Example 3: *Statements*: All pens are tools. No tool is a toy.
Conclusion I: No pen is a toy. *Conclusion II*: Some tools are pens.

Verdict: Conclusion I **follows** ("All-No" chain). Conclusion II also **follows** — since ALL pens are tools, it's always valid to restate this as "some tools are pens" (an "All" statement always guarantees the matching "Some" statement too).

MDCAT Tip: An "All A are B" statement always guarantees "Some A are B" is also true (and "Some B are A" too) — this conversion trick unlocks many conclusions that look tricky at first glance.

Common Trap: "Some A are B" does NOT mean "Some A are not B" — and it definitely doesn't mean "All A are B" either. "Some" only guarantees overlap of at least one member; it says nothing about the rest. Do not assume more than what "some" strictly guarantees.

Common Trap: Two "Some" statements chained together (e.g., "Some A are B" + "Some B are C") guarantee NOTHING about A and C — the "some" B's in each statement might be entirely different individuals. This is the single most common wrong-answer trap in syllogism questions.

60-Second Revision

- "All A are B" = full containment; "No A is B" = zero overlap; "Some A are B" = at least one shared member
- All + All → All follows; All + No → No follows; Some + All → Some follows
- Some + Some → nothing certain follows
- "All A are B" always also guarantees "Some A are B"

QUICK CHECK

1. Statements: All roses are flowers. All flowers are plants. Conclusion: All roses are plants.
   A) Follows B) Does not follow C) Cannot be determined D) Contradicts the statements
2. Statements: Some cups are plates. Some plates are spoons. Conclusion: Some cups are spoons.
   A) Follows B) Does not follow C) Always true D) Definitely false
3. Statements: All keys are metals. No metal is wooden. Conclusion: No key is wooden.
   A) Does not follow B) Follows C) Cannot be determined D) Contradicts the statements

Answers: 1-A, 2-B, 3-B

END OF UNIT 4 — EXAMOO

5 Course of Action

Deciding which next step is genuinely the right one

PMDC Syllabus Theme 5.5 — "A step or administrative decision to be taken for improvement, follow-up, or further action to a problem, policy, etc., based on the information given." Sub-skills: Gathering Information, Using Information for Decisions, Judging Courses of Action

What Makes a Course of Action "Follow" LO 5.5.1–5.5.3

You'll be given a statement describing a problem or situation, followed by one or more suggested "courses of action." You must judge whether each one **logically follows** — meaning it is a sensible, practical, and directly relevant step to take in response to that specific situation. A good course of action should:

- Directly address the problem described (not a vague or unrelated action)
- Be realistic and within reasonable authority to carry out
- Not be excessively extreme or drastic compared to the scale of the problem
- Tackle the root cause where possible, not just a surface symptom

Worked Example 1: *Statement*: "Several students have been arriving late to school because the newly re-routed public bus no longer stops near the school gate."
Course of Action I: "The school should contact the transport authority to request a stop near the school gate."
Course of Action II: "The school should expel all students who arrive late."
Verdict: Course I **follows** (directly addresses the actual root cause). Course II **does not follow** (wildly disproportionate — punishes students for a transport problem outside their control).

Worked Example 2: *Statement*: "A local bakery has received multiple complaints that its bread spoils within a day, much faster than competitors' bread."
Course of Action I: "The bakery should investigate its storage and ingredient practices to find the cause of rapid spoilage."
Course of Action II: "The bakery should immediately shut down permanently."
Verdict: Course I **follows** (proportionate, addresses the root cause first). Course II **does not follow** (an extreme overreaction before even investigating the actual problem).

When BOTH or NEITHER Follow

Not every question has one right and one wrong course — sometimes both suggested actions are reasonable complementary steps (both follow), and sometimes neither properly addresses the actual problem stated (neither follows).

Worked Example 3: *Statement*: "A city's main water treatment plant has been reporting declining water quality due to aging pipelines."
Course of Action I: "The municipal authority should conduct an urgent inspection of the pipeline network."
Course of Action II: "The municipal authority should begin budgeting for pipeline replacement in affected areas."
Verdict: **Both follow** — inspection (immediate, diagnostic) and budgeting for replacement (longer-term fix) are complementary, non-conflicting responses to the same root problem.

STRATEGY CHECKLIST

Step 1	**Identify the actual root problem stated (not what you assume it might be)**
Step 2	**Ask: does this action directly and proportionately address that problem?**

Step 3	**Reject actions that are extreme, vague, or address the wrong issue entirely**
Step 4	**Check if multiple actions can reasonably coexist (both follow) or conflict (only one can)**

MDCAT Tip: A course of action that merely "investigates," "reviews," or "raises awareness" is usually safe and moderate — these tend to follow. An action that is punitive, permanent, or drastic (banning, shutting down, firing everyone) is usually too extreme unless the statement itself describes an extremely severe situation.

Common Trap: Don't reject a course of action just because it seems "too obvious" or "too simple" — MDCAT often tests whether you can recognize that the most direct, sensible response actually IS the correct one, resisting the urge to overthink.

60-Second Revision

- A valid course of action directly, proportionately, and realistically addresses the STATED problem
- Reject extreme, vague, or off-target actions
- Both actions can follow if they're complementary, non-conflicting responses
- Investigative/moderate actions are usually safer bets than drastic ones

QUICK CHECK

1. Statement: "A restaurant has received several complaints about slow service during peak hours." Which course of action follows?
   A) Permanently close the restaurant B) Hire additional staff for peak hours C) Ban customers from complaining D) Ignore the complaints
2. Statement: "A factory's machines have been malfunctioning frequently, causing production delays." Course of Action: "The factory should schedule regular maintenance checks for its machines."
   A) Follows B) Does not follow C) Contradicts the statement D) Is unrelated to the problem
3. A course of action that is disproportionately extreme compared to the problem described should generally be judged as:
   A) Always following B) Not following C) Always the best option D) Irrelevant to judge

Answers: 1-B, 2-A, 3-B

END OF UNIT 5 — EXAMOO

6 Cause and Effect

Untangling which event made the other one happen

PMDC Syllabus Theme 5.6 — "The relationship between two things when one thing makes something else happen." Sub-skills: Reasoning About Incidents/Events, Rejecting False Beliefs, Building Arguments Through Reasoning

The Four Possible Relationships LO 5.6.1–5.6.3

You'll be given two statements (I and II) describing events, and must decide how they relate. There are four standard possibilities to test, in this order:

THE FOUR RELATIONSHIP TYPES

Type A	**Statement I is the CAUSE, Statement II is its EFFECT**
Type B	**Statement II is the CAUSE, Statement I is its EFFECT**
Type C	**Both I and II are independent causes (neither caused the other)**
Type D	**Both I and II are effects of some other, common (often unstated) cause**

Step 1: Check the Timeline

A cause must happen BEFORE its effect. Read both statements and ask: which event, if either, could only have happened as a result of the other one occurring first?

Worked Example 1 (Type A): *I:* "A pipeline burst near the city's main reservoir." *II:* "The city experienced a severe water shortage for three days."
Reasoning: The burst pipeline (I) happened first and directly explains the shortage (II).
Verdict: **I is the cause, II is the effect.**

Worked Example 2 (Type C): *I:* "A heatwave struck the region in June." *II:* "A separate power outage occurred in the same region due to a transformer fault."
Reasoning: Both events happened around the same time, but nothing links a heatwave directly to a transformer fault — they are unrelated, independent events (unless the statement explicitly links heat to the transformer failing, which it does not here).
Verdict: **Both I and II are independent causes/events** (unrelated to each other).

Worked Example 3 (Type D): *I:* "Ice cream sales rose sharply in July." *II:* "The number of people visiting public swimming pools also rose sharply in July."
Reasoning: Neither event causes the other directly — but both are natural effects of the same

underlying factor: hot summer weather.
Verdict: **Both I and II are effects of a common cause** (the summer heat).

MDCAT Tip: If two events are simply happening around the same time with no explained mechanism linking them, resist the urge to force a cause-effect connection — "Type C" (independent) or "Type D" (common cause) is very often the correct answer, not Type A or B.

Common Trap: Correlation is NOT causation. Just because two things happen together or around the same time does not mean one caused the other — this is the single most tested trap in cause-and-effect questions. Always demand a clear, direct mechanism before choosing Type A or B.

Common Trap: Watch the order carefully — students often flip Type A and Type B by misreading which statement is listed first (I) versus which one actually happened first in time. The statement ORDER (I, II) has nothing to do with which is the cause; only the actual events' timeline and logic matter.

60-Second Revision

- Four relationship types: I causes II, II causes I, both independent, both effects of a common cause
- A cause must occur before its effect — check the timeline first
- Correlation (happening together) is not proof of causation
- The listed order (I, II) doesn't determine which is the cause — only the actual logic does

QUICK CHECK

1. Statement I: "A bridge was closed for emergency repairs." Statement II: "Traffic congestion increased significantly on nearby roads." What is the relationship?
   A) I is the cause, II is the effect B) II is the cause, I is the effect C) Both are independent causes D) Both are effects of a common cause
2. Statement I: "Umbrella sales increased in the city." Statement II: "Raincoat sales also increased in the city, during the same week." What is the most likely relationship?
   A) I caused II B) II caused I C) Both are effects of a common cause (rainy weather) D) No relationship is possible
3. Which principle is most important when judging cause-and-effect questions?
   A) Whichever statement is listed first is always the cause B) Correlation always proves causation C) A cause must occur before its effect, and correlation alone isn't proof D) The longer statement is always the cause

Answers: 1-A, 2-C, 3-C

END OF UNIT 6 — EXAMOO

All 6 Logical Reasoning Units Complete!

You've now covered every theme PMDC lists for MDCAT Logical Reasoning — Critical Thinking, Letters & Symbols Series, Logical Deductions, Logical Problems, Course of Action, and Cause and Effect. Every example here was built fresh for you — now go build speed and accuracy by timing yourself on fresh practice sets. Best of luck!

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