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Short Notes — Applied Chemistry

BTEUP Diploma • 1st Semester (First Year — Common Curriculum, All 41 Branches) •
Short Notes
Session 2026-27

Short Revision Notes — prepared by KAMALDNP Academy from the official BTEUP 2026-27 syllabus. This is NOT a BTEUP board paper or publication.

These **short notes on Applied Chemistry** collect the key points of every unit of the official BTEUP 2026-27 syllabus in one place. Each subtopic starts with the definition and then gives the differences, steps and examples from which a complete **5-mark short answer** can be written in the examination.

Use the notes **with your syllabus PDF and the practice paper**: read one subtopic, close the notes and write the answer from memory, then check the key points again. These are **revision notes only** — they revise the subject quickly before the exam and are not a replacement for your textbook or class notes.

Atomic Structure & Bonding

Topics: Atoms, molecules and ions; chemical bonds; the periodic table in brief.

Atoms, molecules and ions

Definitions: An **atom** is the smallest particle of an element that takes part in a chemical reaction; it may or may not exist independently (examples: H, O, Fe, Na). A **molecule** is the smallest particle of an element or a compound that can exist independently and shows all the properties of that substance — it is a group of two or more atoms held together, for example H_2 , O_2 , H_2O , CO_2 . An **ion** is a charged particle formed when an atom or group of atoms gains

or loses electrons: a positively charged **cation** (Na^+ , Ca^{2+} , NH_4^+) and a negatively charged **anion** (Cl^- , SO_4^{2-} , OH^-).

Numbers that describe an atom: atomic number Z = number of protons; mass number A = protons + neutrons. **Isotopes** have the same Z but different A . A chemical symbol is written ${}^A_Z\text{X}$.

The mole: one mole of any substance contains 6.022×10^{23} particles (atoms, molecules or ions) — Avogadro's number. The mass of one mole in grams equals the atomic or molecular mass, for example 18 g of water is one mole of H_2O . In an answer, keep the three definitions separate and give one example of each — mixing up atom and molecule is the most common error in this topic.

Chemical bonds

Definition: A chemical bond is the force that holds two or more atoms together in a molecule or compound. Atoms bond to complete their outermost shell (usually eight electrons — the octet rule) and become stable.

Ionic (electrovalent) bond: formed by the complete **transfer** of electrons from a metal to a non-metal, producing oppositely charged ions that attract each other — example: sodium gives one electron to chlorine to form NaCl ; MgCl_2 and CaO are similar. **Covalent bond:** formed by the **sharing** of electron pairs between atoms, usually of non-metals — single bond in H_2 and CH_4 , double bond in O_2 , triple bond in N_2 . **Metallic bond**, in brief, is the attraction between positive metal ions and the surrounding free electrons in a metal, which explains its conductivity and malleability.

Ionic versus covalent compounds:

- Ionic: hard, crystalline, high melting and boiling points, soluble in water, conduct electricity when molten or in solution but not as solids.
- Covalent: soft, low melting and boiling points, generally insoluble in water but soluble in organic solvents, and non-conductors of electricity.

Finish an answer with one daily-life example of each type, such as common salt (ionic) and sugar or methane (covalent).

The periodic table in brief

Definition: The periodic table is the arrangement of all known elements in order of increasing atomic number, in horizontal rows called **periods** and vertical columns called **groups**, so that elements with similar properties fall together. It is based on the **modern periodic law**: the physical and chemical properties of elements are a periodic function of their atomic numbers. (Mendeleev's earlier table used atomic mass.)

Layout in brief: there are 7 periods and 18 groups. Elements are also grouped into four blocks by their electronic structure: the s-block (groups 1–2, active metals), p-block (groups 13–18, metals, non-metals and noble gases), d-block (transition metals, groups 3–12) and f-

block (inner transition elements, placed below the main table). Metals lie on the left, non-metals on the right, with metalloids such as silicon and germanium along the dividing line.

Periodic trends (most asked):

- **Atomic size** decreases across a period (increasing nuclear charge pulls electrons in) and increases down a group (new shells are added).
- **Metallic character** decreases across a period and increases down a group; non-metallic character does the opposite.
- **Electronegativity** (electron-attracting power) increases across a period and decreases down a group; fluorine is the most electronegative element.

Likely question: Define atom, molecule and ion with two examples each, or differentiate between ionic and covalent compounds on any five points with examples.

Water Technology

Topics: Hardness of water; water treatment methods; boiler feed water.

Hardness of water

Definition: Hard water is water that does not produce a good lather with soap easily, because it contains dissolved salts of calcium and magnesium. These salts react with soap to form an insoluble scum (curd) instead of lather, wasting soap; soft water, free of these salts, lathers readily.

Causes and types:

- **Temporary (carbonate) hardness** — due to dissolved bicarbonates, $\text{Ca}(\text{HCO}_3)_2$ and $\text{Mg}(\text{HCO}_3)_2$. It is removed by simple boiling, which decomposes the bicarbonates into insoluble carbonates: $\text{Ca}(\text{HCO}_3)_2 \rightarrow \text{CaCO}_3 \downarrow + \text{H}_2\text{O} + \text{CO}_2 \uparrow$. It is also removed by adding lime (Clark's method).
- **Permanent (non-carbonate) hardness** — due to dissolved chlorides and sulphates, CaCl_2 , MgCl_2 , CaSO_4 and MgSO_4 . Boiling does not remove it; chemical methods such as lime-soda, zeolite or ion-exchange are needed.

Units: hardness is expressed as parts per million (ppm), meaning mg per litre expressed as equivalent CaCO_3 , whatever salt is actually present.

Disadvantages: wastage of soap in washing; scale formation in boilers and pipes; stains and damage to fabrics; poor cooking and dyeing results. Hardness is estimated in the laboratory by titration with a standard EDTA solution.

Water treatment methods

Definition: Water treatment means removing suspended impurities, dissolved salts, colour, odour and disease-causing germs from natural water so that it becomes fit for drinking (municipal supply) or for industrial use such as boiler feed.

Municipal treatment — steps in order:

- **Screening** — a mesh removes floating matter such as leaves and fish.
- **Sedimentation** — water rests in large tanks so heavy suspended particles settle down.
- **Coagulation** — alum is added; its flocs collect fine suspended and colloidal particles, which then settle quickly.
- **Filtration** — water passes through beds of sand and gravel, removing the remaining fine matter and many germs.
- **Disinfection (sterilisation)** — germs are killed by chlorination (chlorine or bleaching powder, the most common method), ozonation or ultraviolet rays.

Softening methods for removing hardness: the **lime-soda process** (calculated quantities of lime and soda ash precipitate both temporary and permanent hardness as CaCO_3 and $\text{Mg}(\text{OH})_2$), the **zeolite (permutit) process** (sodium zeolite exchanges its Na^+ ions for Ca^{2+} and Mg^{2+} ; the exhausted zeolite is regenerated with common-salt solution), and the **ion-exchange process**, which removes cations and anions through two resins and gives fully demineralised water.

Boiler feed water

Definition: Boiler feed water is the water supplied to a boiler to be converted into steam. Because a boiler concentrates whatever the water carries, this water must be specially treated — even small amounts of hardness, dissolved gases or oil cause serious trouble at high temperature and pressure.

Requirements of boiler feed water: it should be soft (free from hardness-producing salts), free from dissolved oxygen and carbon dioxide, free from oil and suspended matter, and neither strongly acidic nor carrying excess alkali.

Troubles caused by untreated water:

- **Scale** — a hard, adherent deposit of CaSO_4 , CaCO_3 and magnesium salts on boiler walls; it is a poor conductor of heat, so fuel is wasted and plates may overheat and crack.
- **Sludge** — a soft, loose, slimy precipitate formed in cooler parts; it can be removed by blow-down, unlike scale.
- **Priming and foaming** — priming is the carrying of water droplets with steam; foaming is the formation of persistent bubbles on the water surface, caused by oil and dissolved solids; both give wet steam and damage engines and turbines.
- **Caustic embrittlement** — cracking of boiler metal caused by concentrated alkali (caustic soda) collecting in crevices and rivet joints; prevented by keeping the water only mildly alkaline, for example with sodium phosphate.

Likely question: Differentiate between temporary and permanent hardness of water, state the disadvantages of hard water, and describe the lime-soda process of softening with the reactions involved.

Fuels & Combustion

Topics: Types of fuels; calorific value; combustion and its control.

Types of fuels

Definition: A fuel is a combustible substance that, on burning in air or oxygen, produces a large amount of heat energy that can be used for cooking, heating, running engines or generating power. Most fuels contain carbon and hydrogen as their principal combustible elements.

Classification by physical state:

- **Solid fuels** — wood, coal, coke, charcoal. Cheap and easy to store, but high in ash, slow to ignite and of comparatively low calorific value.
- **Liquid fuels** — petrol, diesel, kerosene, furnace oil. Higher calorific value, no ash, easy to transport through pipes and control; obtained mostly from petroleum.
- **Gaseous fuels** — LPG, CNG, natural gas, biogas, water gas, producer gas. Highest ease of control, complete and smokeless burning and no ash, but they need special storage and carry a leakage risk.

Classification by origin: **natural (primary) fuels** occur ready in nature — wood, coal, petroleum and natural gas; **artificial (secondary) fuels** are prepared from them — coke, charcoal, petrol, diesel, LPG and biogas. In a comparison answer, judge any fuel on calorific value, ignition temperature, ash content, storage and cleanliness of burning.

Calorific value

Definition: The calorific value of a fuel is the total amount of heat produced when one unit mass (or unit volume, for gases) of the fuel is burnt completely and the products of combustion are cooled to the original temperature. For solid and liquid fuels it is expressed in kcal/kg or kJ/kg; for gases, in kcal/m³.

Two values, and the difference that is always asked:

- **Gross (higher) calorific value, GCV** — the total heat obtained when the products are cooled so that the steam formed from the hydrogen of the fuel condenses, giving up its latent heat as well.
- **Net (lower) calorific value, NCV** — the heat actually available when the steam escapes as vapour, as happens in practice. $NCV = GCV - \text{latent heat of the steam formed (about } 0.09 \times H_2 \times 587 \text{ kcal/kg, where } H_2 \text{ is the percentage of hydrogen in the fuel)}$.

So GCV is always greater than NCV for a hydrogen-containing fuel. Calorific value is measured in the laboratory with a **bomb calorimeter**, and approximately calculated from the ultimate analysis by **Dulong's formula**: $GCV \approx (1/100)[8080C + 34500(H - O/8) + 2240S]$ kcal/kg, where C, H, O and S are the percentages of carbon, hydrogen, oxygen and sulphur. Remember also 1 kcal = 4.186 kJ for unit conversion.

Combustion and its control

Definition: Combustion is a rapid chemical reaction of a fuel with oxygen (oxidation) in which heat and light are produced — in simple terms, burning. Three things must be present together: a combustible fuel, a supply of oxygen (air), and heating of the fuel to its **ignition temperature**, the minimum temperature at which it catches fire.

Complete and incomplete combustion: with sufficient air, carbon burns completely: $C + O_2 \rightarrow CO_2 + \text{heat}$, and the full calorific value is obtained. With insufficient air, burning is incomplete: $2C + O_2 \rightarrow 2CO$, producing **carbon monoxide**, a colourless, odourless and highly poisonous gas, and wasting fuel as soot and smoke.

Control of combustion means burning the fuel completely, safely and economically:

- Supply the correct quantity of air — a little excess air ensures complete burning, but too much excess air carries heat away with the flue gases.
- Maintain proper temperature and good mixing of fuel and air (turbulence), and allow enough time and furnace space for burning to finish.
- Analyse the flue gases regularly (for CO_2 , O_2 and CO) to detect incomplete combustion early.
- Keep heating surfaces clean of soot and scale, and control the rate of firing so that smoke and unburnt fuel are minimised.

Likely question: Classify fuels with one example of each type, or write a short note on the characteristics of a good fuel and compare solid, liquid and gaseous fuels.

Corrosion & Its Prevention

Topics: What corrosion is; types of corrosion; methods of prevention.

What corrosion is

Definition: Corrosion is the gradual destruction or eating away of a metal by the chemical or electrochemical action of its environment — air, moisture, acids, gases or soil — starting at its surface. The metal slowly returns to a combined form such as an oxide, carbonate or sulphide, which is its natural, more stable state.

Rusting of iron is the most familiar example: iron exposed to moist air forms a reddish-brown, flaky layer of **rust, hydrated ferric oxide, $Fe_2O_3 \cdot xH_2O$** . Both oxygen and moisture are necessary for rusting — iron does not rust in dry air or in air-free water.

Effects and losses: corrosion weakens structures, bridges, pipelines, ships and machine parts, reduces their life and efficiency, contaminates products in chemical plants, and causes heavy economic loss through repair and replacement. A few metals behave oppositely: aluminium and chromium form a thin, tight oxide film that protects the metal below from further attack — a fact worth adding to any answer on this topic.

Types of corrosion

Definition: Corrosion is classified by its mechanism and by the pattern of attack. Naming the type correctly, with its cause and one example, is what a short answer on this topic requires.

By mechanism:

- **Dry or chemical corrosion** — direct chemical attack by gases such as oxygen, chlorine or hydrogen sulphide, forming an oxide or other film on the metal surface; common at high temperatures.
- **Wet or electrochemical corrosion** — occurs when the metal is in contact with moisture or an electrolyte; tiny galvanic cells form on the surface, one part acting as anode (where the metal dissolves, that is, oxidation occurs) and another as cathode (where oxygen is reduced). Rusting of iron in moist air is of this type; it is far more common and damaging than dry corrosion.

By pattern of attack: **uniform corrosion** spreads evenly over the surface; **pitting corrosion** concentrates at small spots and makes deep holes, which is especially dangerous because the part looks almost sound; **galvanic corrosion** attacks the more active metal when two different metals touch in the presence of moisture; **stress corrosion** cracks a metal held under stress in a corrosive medium.

Methods of prevention

Definition: Corrosion is prevented either by separating the metal from its environment, by making the metal itself resistant, or by reversing the electrochemical action that dissolves it. A complete answer names methods from all three ideas.

Protective coatings (barrier methods):

- **Paints, varnish, enamel, tar, oil and grease** cut off air and moisture; simple and cheap, but protection ends wherever the film breaks.
- **Metallic coatings** — hot-dip **galvanisation** coats iron with zinc, which being more active corrodes in preference and so protects the iron even where the coating is scratched; **tinning** coats with tin for food containers (but a scratch then speeds up rusting); **electroplating** deposits chromium, nickel or zinc for protection with a bright finish.

Other methods: **alloying** — adding chromium and nickel to iron gives stainless steel, which resists corrosion by its own surface film. **Cathodic protection** — the structure (a buried pipeline, a ship's hull) is connected to a more active metal such as magnesium or zinc, the **sacrificial anode**, which corrodes instead; or a direct current from an external source is impressed to make the structure a cathode. **Corrosion inhibitors** — chemicals added in

small quantities to the water or stored liquid slow the attack. Finally, proper design (avoiding crevices and trapped water) and choosing the right metal for the environment prevent corrosion before it starts.

Likely question: Define corrosion, explain the electrochemical theory of rusting of iron with the anode and cathode reactions, and state any five methods of preventing corrosion.

Quick Revision — One Line Each

- An atom takes part in chemical reactions as a whole; a molecule exists independently; an ion carries a charge — cation positive, anion negative.
- One mole of any substance contains 6.022×10^{23} particles (Avogadro's number).
- Ionic bonds transfer electrons (NaCl: hard, high melting, conduct when molten); covalent bonds share electrons (CH₄: soft, low melting, non-conductors).
- Modern periodic law: properties are a periodic function of atomic number; 7 periods, 18 groups.
- Across a period atomic size and metallic character decrease; down a group both increase.
- Temporary hardness is due to bicarbonates of calcium and magnesium and is removed by boiling; permanent hardness is due to their chlorides and sulphates and is not.
- Hardness is expressed in ppm, that is mg per litre expressed as CaCO₃.
- Boiler troubles to name together: scale, sludge, priming and foaming, caustic embrittlement and corrosion.
- A good fuel has high calorific value, moderate ignition temperature, low ash, moisture and sulphur, and burns steadily without harmful smoke.
- Gross calorific value counts the latent heat of the steam formed; net calorific value does not — so GCV is always higher than NCV.
- Complete combustion needs fuel, oxygen and ignition temperature together; shortage of air gives poisonous carbon monoxide instead of carbon dioxide.
- Rust is hydrated ferric oxide, Fe₂O₃·xH₂O; corrosion at the anode is oxidation of the metal.
- Galvanisation coats iron with zinc, which protects even when scratched; cathodic protection makes the structure the cathode using a sacrificial anode of magnesium or zinc.

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