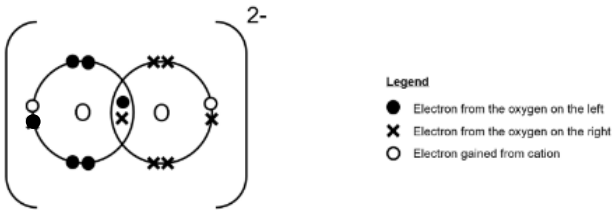
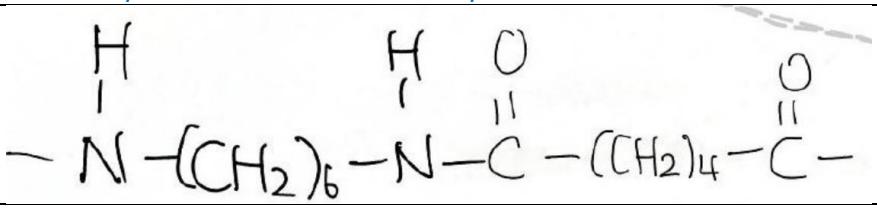
2023 Chemistry O level (Suggested Answers) Paper 2

Qn / part	Suggested answer *and comment*
	Section A
A1(a)	Y: 2; Li^+ Z: VI (Group 16), Se^{2-} *Y is an ion and not an atom, therefore Y cannot be Helium.*
(b)	X/F^-. It has 10 neutrons and 9 protons, so it has a relative atomic mass of 19, same as that in the Periodic Table. *Must show how information in the table leads to the conclusion that X has a relative atomic mass of 19.*
(c)	Helium
(d)	Aqueous bromine remains red-brown. Bromine is less reactive than fluorine and is unable to displace fluorine from its halide solution. *Halogen and halide ions are not the same. It is fluorine (not fluoride) that is more reactive than bromine (not bromide).* $Br_2(aq)_{brown} + F^-(aq) \rightarrow$ *no reaction* *remains brown* $F_2(aq) + 2Br^-(aq)_{colourless} \rightarrow 2F^-(aq) + Br_2(aq)_{brown}$
A2(a)	product at negative electrode: Ag/silver product at positive electrode: O_2/oxygen
(b)	When electricity passes through the platinum electrodes, the electric current is conducted by the free-moving "sea of delocalised electrons". When electricity passes through the solution, the electric current is conducted by the free-moving silver, Ag^+ and nitrate, NO_3^- ions. *Question is referring to electrical conductivity through different structure (metal vs ionic compound in solution). Students mistake question and explain which ions were discharged instead which is already asked in (a)* *Delocalised does not describe free-moving.*
(c)	compound: HNO_3/nitric acid explanation: OH^- and Ag^+ ions are preferentially discharged at the anode and cathode, respectively, leaving behind H^+ and NO_3^- ions, which combine to form HNO_3 which turns the Universal Indicator red. *Hydrogen ion is not a compound.*

	Explain why UI turns red – presence of acid – state where H^+ ions formed – explain why H^+ remains in the electrolyte (must mention what was discharged from the electrolyte.
(d)(i)	hydrogen
(d)(ii)	H^+ ions are discharged at the cathode and reduced to form hydrogen gas. At the start, Ag^+ ions from the electrolyte are preferentially discharged over H^+ at the cathode / negative electrode to form silver metal as silver is less reactive than hydrogen. *Wrong phrasing: Silver ions are less reactive than hydrogen ions.* *Correct phrasing: Silver that is less reactive than hydrogen, which results in Ag^+ ions being preferentially discharged over H^+.*
A3(a)(i)	$4CuFeS_2 + 11\ O_2 \rightarrow 4Cu + 2Fe_2O_3 + 8SO_2$ *Check balancing and know your formulae well! Common carelessness include mistaking iron(II) oxide*
(a)(ii)	1 tonne = 1000 kg = 1000000 g Mr of $CuFeS_2$ = 64 + 56 + 32 x 2 = 184 Composition by mass = $\frac{64}{184}$ x 1000000 g = 348000 g or 348 kg or 0.348 tonnes (3 s.f.)
(b)(i)	acid: SiO_2/silicon dioxide/silicon(IV) oxide base: Fe_2O_3/iron(III) oxide
(b)(ii)	Extraction of copper: SiO_2 is added to the furnace to react with iron(III) oxide, which is the impurity, to form slag. Extraction of iron: $CaCO_3$ is added to the blast furnace, which is decomposed by heat to form CaO and CO_2. CaO then reacts with SiO_2, the impurity, to form slag. *Blast furnace is not in new syllabus. However students must know that this is an example of acid-base reaction*
(c)	$4CuO + CH_4 \rightarrow 4Cu + CO_2 + 2H_2O$ $3\ CuO + CH_4 \rightarrow 3Cu + CO + 2H_2O$ carbon monoxide/CO, carbon dioxide/CO_2, water/H_2O (any 2) *Question says 'other' so copper is not accepted*

A4(a)	(a) The ratio of atoms of metal to atoms of oxygen decreases from 2:1 in Li_2O to 1:1 in Na_2O_2 to 1:2 in KO_2. *Some students did not simplify the 2:2 ratio to 1:1. Many failed to describe the trend as required and merely stated the number of metal and oxygen atoms in each formulae.*
(b)	 *Common mistakes:* - *did not show the two additional electrons (one gained by each atom) that resulted in the 2- charge.* - *drawing separate ions instead of a polyatomic ion*
(c)(i)	O_2^-
(c)(ii)	One of the oxygen atoms only has 7 valence electrons instead of a fully filled valence shell of 8 electrons. *Oxygen normally forms a molecule with 8 electrons in the outermost shell after sharing a double bond.* *However, when the pair shared a single bond, it has 7 electrons in the outermost shell. (hence this dows not follow normal bonding rules)* *The molecule must gain 2 electrons to form a superoxide ion with a -2 charge.* *Some students thought that an 'odd number of electrons are shared' in the superoxide ion, which is incorrect.*
(d)(i)	Metal oxides react with water to produce metal hydroxides *(specifically Group 1 metal hydroxides)* which are soluble in water and dissolve in water to form alkalis, which turn red litmus blue. Both metal peroxide and superoxides react with water to form hydrogen peroxide, which bleaches the litmus indicator to turn colourless. When metal superoxide reacts with water, oxygen gas is also formed, which gives rises to the formation of bubbles/effervescence. *Some students did not consider the information that hydrogen peroxide is bleach carefully, which lead them to think that hydrogen peroxide neutralizes the solution, which is incorrect. Some students only explained one or two observations, instead of all three.*

(d)(ii)	$2\ KO_2 + 2H_2O \longrightarrow 2KOH + H_2O_2 + O_2$
A5(a)	Photosynthesis
(b)	A *(produce oxygen)*
(c)	B. $CO_2(g)$ dissolves in water to form $CO_2(aq)$, and vice versa or there is a forward and backward arrow. *Avoid reusing the term 'reversible' in the answer.* *This process is not a chemical reaction.*
(d)	$CO_2(g)$ dissolves in water to form $CO_2(aq)$. $CO_2(aq)$ evaporates to form $CO_2(g)$. *Some students only gave one change in one direction, instead of both directions.*
(e)	A: endothermic C: exothermic D: exothermic
(f)	Process A (photosynthesis) takes in CO_2 from the air whereas process B produces $CO_2(g)$ from $CO_2(aq)$ through ocean uptake and evaporation. The decrease in the concentration of CO_2 in the air due to process A is offset by process B, resulting in the stabilisation of the concentration of carbon dioxide in the air. *Many students failed to refer to processes A and B in their answers, or included other processes such as combustion of fossil fuels or respiration.* *Do not repeat the statement in the question.*
A6(a)	
(b)	Similarity: Dicarboxylic acid and another monomer is used to make both polymers undergo a condensation reaction to form the polymer product with the removal of water. Difference: The monomers used to make this polymer are a dicarboxylic acid and a diol, whereas the monomers used to make the polymer in (a) are a dicarboxylic acid and a diamine. *Some students compared the polymers and their linkages, rather than the monomers.*
(c)(i)	A macromolecule consists of many covalent molecules joined together to form a long molecular chain.
(c)(ii)	Condensation polymerisation involves the removal of small molecules such as water, whereas addition polymerisation does not involve the removal of small molecules.

	Addition polymerisation involves monomers with a C=C bond whereas condensation polymerisation involves monomers with –COO and –OH/-NH_2 groups. Addition polymerisation produces a polymer with the same empirical formula as the monomers, whereas condensation polymer does not produce a polymer with the same empirical formula as the monomers. *Comment: Some students mentioned about the 'elimination of atoms', which is incorrect.*
	Section B
B7(a)	The impurity ethanoic acid is produced from the oxidation of ethanol by bacteria in the air, which is the product from the fermentation of sugar from sugarcane. The impurity ethyl ethanoate is produced from the esterification reaction between ethanol, which is the product from the fermentation of sugar from sugarcane, and ethanoic acid, which is the impurity produced from the oxidation of ethanol. *Comment: Some students only described the formation of one, but not both, of the impurities. Some did not clearly identify the impurities. Some did not fully engage with the context of the question and the discussed laboratory conditions for the formation of the compounds.*
(b)	Ethanol produced from the fermentation of sugarcane is considered to be 'carbon neutral' because sugarcane absorbs carbon dioxide from the air during photosynthesis and when ethanol undergoes combustion, carbon dioxide is released back into the air. It is also considered to be renewable as sugarcane can be regrown and replaced in a short period of time. However, ethanol produced from the cracking of naphtha is not 'carbon neutral' because the process requires a high temperature of 300°C, which is maintained by burning fossil fuels that release carbon dioxide into the air. Naphtha is also obtained from petroleum, which is a non-renewable source of energy. *Comment: Many students failed to justify why the people's views are incorrect. Some students incorrectly supported the idea of ethanol being carbon neutral, typically focusing too much on the renewable aspect and leaving out ethanol production from cracking of naphtha.*
(c)(i)	Percentage by mass of oxygen in E70 fuel (70% C_2H_5OH by mass) $= \frac{16}{2\times12+5\times1+16+1} \times 100\% \times 70\%$ = 24.3% (3 s.f.) *Comment: Some students did not consider that E70 fuel is not pure ethanol, but only contains 70% ethanol by mass.*

(c)(ii)	It increases the likelihood for complete combustion to take place, which prevents the formation of air pollutants such as carbon monoxide as a result of incomplete combustion. *Comment: Some students merely quoted from the information provided without explaining the advantage.*
(d)	GGE of LPG = 34200 ÷ 26500 = 1.3 (1 d.p.) This means that 1.3 L of space is required to store LPG that provides the same energy output as 1 L of petrol. More storage space is required for LPG compared to petrol for the same energy output. *Comment: Some students incorrectly assumed that LPG is a gaseous fuel despite the L standing for 'liquified'.*
(e)	Enthalpy change of combustion of octane = -5470 kJ/mol (5470 kJ/mol of energy released) Mass density of petrol = 0.75 g/cm^3 = 750 g/L In 1 L of petrol, there are $\frac{750\ \text{g}}{(8\times12+18\times1)\ \text{g/mol}}$ = 6.5789 mol of octane Energy density per L of petrol = 5470 kJ/mol × 6.5789 mol = 36 000 kJ/L (3 s.f.) *Comment: It was common to see one of the steps omitted.*
B8(a)	*Using 'ideas about particles':* - *apply Kinetic particle theory* - *name the particles specifically* - *describe at the micro level the collision theory (how it affects frequency of effective collisions)* *From the question, the 3 experiments can be compared by:* *Exp 1 VS Exp 2 (dibasic vs monobasic but both strong acids of same concentration and at same temperature)* *Exp 2 VS Exp 3 (different temperature but same concentration)* *Answers must be in complete sentences and plan the way you write. State which experiment to compare based on difference in volume collected by explanation.* Experiment 1 produces a larger volume of gas than experiment 2 after 30s. H_2SO_4 is a strong dibasic acid while HC*l* is a strong monobasic acid. 1 mol/dm^3 H_2SO_4 produces double the concentration of H^+ ions of the same concentration of HC*l* at the same temperature of 20°C. There are more H^+ ions per unit volume in H_2SO_4, hence frequency of effective collisions increases resulting in a faster rate of reaction compared to HC*l*. Experiment 3 produces the largest volume of gas and greater than experiment 2 after 30s.

	The higher temperature results in an increase in the kinetic energy of H^+ ions, so more H^+ ions will possess greater than or equal to the activation energy for the reaction between HC*l* and Zn to take place. The frequency of effective collisions between the H^+ ions and Zn increases, and hence rate of reaction increases. *Comment: Many students did not explain their answers in terms of particle theory. Some had contradicting points or omitted points.*
(b)(i)	$Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$
(b)(ii)	Zn loses electrons to form Zn^{2+}, and is oxidised. H^+ ions gain electrons to form H_2, and are reduced. or The oxidation state of zinc increases from 0 in Zn to +2 in Zn^{2+}, so zinc is oxidised. The oxidation state of hydrogen decreases from +1 in H^+ to 0 in H_2, so hydrogen ion is reduced. Since oxidation and reduction occurred simultaneously, this is a redox reaction. *Comment: Common errors include use of ambiguous language such as 'hydrogen is reduced' rather than 'hydrogen ion gain electrons' and mistaking the oxidation of zinc ion as +1.* *Some students did not mention how the redox occur.*
(c)	1. Add excess solid zinc to 50 cm^3 of 1.0 mol/dm^3 HC*l* at room temperature 2. Measure the volume of gas collected in 30 s using a gas syringe 3. Repeat steps 1-2, with the addition of 1 g of copper as the catalyst, keeping all other variables constant. 4. Measure the volume of gas collected in 30 s using a gas syringe. 5. Compare the volume of gas collected. The experiment with copper catalyst should produce a larger volume of gas in 30 s. *Comment: Some students gave descriptions that were unclear or did not indicate the results to be expected. Some suggested other ways that deviated from the experimental results in the form given in the table (ie, rate of gas collection)* *Many students did not mention any control variables in their experiment, and it is not enough to say 'Repeat using copper', rate of reaction increases.* *Note that catalyst does not increase yield, but produces* ***more gas per unit time*** *(different measurement)* *Stronger students would also be able to mention that mass of copper remains unchanged as it is a catalyst.*
Either B9(a)(i)	Hydrogen gas and zinc oxide *Some students left the answer as 'metal oxide' when zinc is already in the question.*

	Common mistake is to give zinc hydroxide (only Group 1 metal react with cold water to give Group 1 hydroxide)
(a)(ii)	Mass of solid increases as zinc metal gained oxygen to form solid zinc oxide. *Comment: Some students did not attribute the increase in mass due to the gain of oxygen. Common misconception is to state the zinc gained oxygen from air (question is reaction with steam)*
(b)(i)	name: calcium nitrate formula: $Ca(NO_3)_2$
(b)(ii)	Nitrate ion: Add aqueous sodium hydroxide, then add a piece of aluminium and warm the mixture carefully. Effervescence is observed. Test the gas given off with a piece of damp red litmus paper. If it turns blue, the gas is ammonia and nitrate ions are present. Calcium ion: Add a few drops, then excess aqueous sodium hydroxide. A white precipitate is formed that is insoluble in excess. *Comment: Some students omitted the observations in excess NaOH required to identify calcium ion. Some incorrectly used aqueous ammonia as the reagent to identify calcium ion. (a common reagent is sodium hydroxide)* *Plan your answers and identify which test is for which ion*
(c)	The volume of gas formed when calcium reacts with steam will be 50 cm^3 (>40 cm^3). Calcium is a more reactive metal than zinc and reacts more readily with steam to produce a larger volume of hydrogen gas in 2 minutes. The volume of gas formed when copper reacts with steam will be 0 cm^3. Copper is an unreactive metal and is unable to react with steam to produce a gas. *Predict means give a value, do not merely state whether more or less gas was formed.* *Common misconception is that copper would give 'less gas' because 'copper is less reactive than zinc'.*
Or B9(a)(i)	State: The time taken for the white precipitate is form is the fastest for copper(II) carbonate and slowest for zinc carbonate. Explain: The more reactive the metal, the more thermally stable its carbonate. It is more difficult to thermally decompose the carbonate of a more reactive metal, so the time taken for the white precipitate to form is the longest, and vice versa. *Comment: Many students did not make a link between the reactivity of the metal and the ease of decomposition of its carbonate.* *Zinc is more reactive than copper, not zinc carbonate is more reactive than copper(II) carbonate → only compare reactivity of the metal* *Also wrong to say zinc is more thermally stable.*
(a)(ii)	The first reagent is aqueous ammonia. Add a few drops of aqueous ammonia, then in excess. If Cu^{2+} ions are present, a light blue precipitate is formed that dissolves in excess to form a dark blue solution. If Zn^{2+} ions are

	present, a white precipitate is formed that dissolves in excess to form a colourless solution. If Pb^{2+} ions are present, a white precipitate is formed that is insoluble in excess. The second reagent is dilute sulfuric/hydrochloric acid (or any soluble solution with sulfate or chloride ions). If Cu^{2+} ions are present, a blue solution will be formed. If Zn^{2+} ions are present, a colourless solution is formed. If Pb^{2+} ions are present, a white precipitate is formed. *Comment: Many students did not describe the effect of the addition of excess aqueous ammonia on the colour or solubility of the precipitate.* *Sodium hydroxide cannot be used because both Zn^{2+} and Pb^{2+} give the same result* *Many fail to identify that Zn^{2+} and Pb^{2+} can be differentiated using precipitation.* *Some poorly planned answers and little structure.* *Describe similarities and differences separately.*
(a)(iii)	Describe: **Red-brown solid** is formed on solid magnesium metal and **blue solution is decolourised.** Explain: **Magnesium is more reactive than copper and displaces copper from the solution** containing Cu^{2+} ions. Mg^{2+} solution is colourless. *Common mistakes: magnesium displaces Cu^{2+} ion ; red brown precipitate is formed*
(b)	$MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$
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