2025 S4 Preliminary Examination
Suggested Solutions

Answer Key

1	2	3	4	5	6	7	8	9	10
C	**B**	**C**	**D**	**C**	**A**	**C**	**D**	**C**	**D**
11	12	13	14	15	16	17	18	19	20
D	**B**	**D**	**B**	**B**	**D**	**B**	**B**	**A**	**A**
21	22	23	24	25	26	27	28	29	30
A	**D**	**A**	**B**	**A**	**C**	**C**	**D**	**B**	**C**
31	32	33	34	35	36	37	38	39	40
A	**C**	**A**	**A**	**D**	**C**	**B**	**A**	**B**	**D**

1 **C**

Why C: To make a dry acidic gas like SO_2 from solid + acid, you need a delivery tube → drying agent that doesn't react with SO_2 (conc. H_2SO_4 or anhydrous $CaCl_2$) → downward delivery (SO_2 is denser than air).

Why not A/B/D:
A: Basic CaO will react with acidic SO_2 gas.

B: Using the filter funnel will allow the SO_2 gas to escape.

D: Upward delivery method is used for gases less dense than air.

2 **B**

Why B: Iodine is a substance that sublimes (changes directly from solid to purple vapour without melting).

Sodium chloride (NaCl) does not sublime; it has a very high melting point and remains solid.

By heating the mixture gently, iodine vapour can be driven off, collected and cooled back into solid iodine crystals. Sodium chloride stays behind as a solid.

Why not A/C/D:
A: Both iodine and sodium chloride are solids, not dissolved in a solution, so crystallisation is not suitable.
C: Works only to separate insoluble solid from liquid, not two solids.
D: Used to separate liquids with different boiling points, not solid mixtures like this.

3 **C**

Step 1: Interpreting statement 1
Z shows four distinct spots on the chromatogram.
That means Z contains at least four different components**.**
It cannot be "no more than four" because there could be more that did not separate under the given solvent conditions.
So, statement 1 must be "Z contains at least four alcohols".

Step 2: Interpreting statement 2
If spots from X, Y and Z line up at the same R_f values, that suggests those mixtures may contain a common alcohol.
Therefore, it is possible they share the same substance.
So, statement 2 = "X, Y and Z could contain the same alcohol".

4 **D**

Statement 1: Molecules gain kinetic energy and temperature increases.
Wrong. During melting, the temperature stays constant at 0 ºC. The particles don't gain kinetic energy; instead, energy goes into overcoming intermolecular forces of attraction.

Statement 2: Energy is gained to overcome the intermolecular forces of attraction.
Correct. Heat energy supplied during melting is used to overcome intermolecular forces of attraction.

Statement 3: Molecules gain sufficient energy to move from fixed positions.
Correct. Solid ice particles are in fixed positions. When melting, they break free and can slide past each other.

5 **C**

The lighter the gas, the faster it diffuses.

Cl_2: 35.5 × 2 = 71
CO_2: 12 + (16 × 2) = 44
CH_4: 12 + (1 × 4) = 16
NO_2: 14 + (16 × 2) = 46

The smallest M_r = 16 (CH_4). Hence, CH_4 diffuses the fastest.

6	A	
✓	A	Proton charge = +1 Electron charge = –1 Equal magnitude, opposite signs.
×	B	Neutron has 0 charge, not +1.
×	C	Neutron = 1 (relative mass). Electron = $\frac{1}{1840}$ so it's much lighter, not heavier.
×	D	Proton = 1 and Electron = $\frac{1}{1840}$

7	C	
×	A	Isotopes of an element have the same number of electrons → same electronic configuration → same chemical properties. They may differ in physical properties (e.g. density, boiling point), but not in chemistry reactions.
×	B	Isotopes differ in number of neutrons. They have the same chemical properties but physical properties are different.
✓	C	mass number = protons + neutrons Different isotopes differ in number of neutrons hence, they have different mass numbers. Different isotopes have the same number of electrons hence, they have the same electronic configuration, same chemical properties.
×	D	If the proton numbers are different, they are different elements instead not isotopes.

8	D	
×	1	W is 2+ not 2–.
×	2	Should be W_3Y_2
✓	3	WZ_2 is $MgCl_2$

9	C	
×	1	Giant covalent (e.g. diamond, SiO_2) → high mp but do not conduct electricity at all (except graphite).
✓	2	Example: CO_2, I_2. Weak intermolecular forces → low melting point. No free ions/free delocalised electrons → does not conduct electricity
✓	3	Metals conduct due to delocalised electrons in both states. Different metals have different melting points.

10	D Use trial and error method

11	D Why right: Molecular formula + Ar values gives Mr directly. Why others wrong: Empirical formula or % by mass alone isn't enough to get molecular mass.

12	B % Cu in $CuFeS_2$ = $\frac{64}{64+56+2(32)} \times 100 = 34.782\%$ If ore has 1% Cu, % = (1 ÷ 34.782) x 100% = 2.88%

13	D no. mol of B = $\frac{0.78}{11} = 0.070909$ no. mol of C = $\frac{0.22}{12} = 0.018333$ Ratio of B:C ≈ 4:1 B_4C

14	B no. mol of Q molecules = $\frac{1}{x}$ no. of Q molecules = $\frac{1}{x} \times L = \frac{L}{x}$ no. of Q atoms = 2 x $\frac{L}{x} = \frac{2L}{x}$

15	B To neutralise acidic soil, add a base (alkali). Reasoning: • Calcium hydroxide is a strong base used in agriculture ("liming"). • Neutralisation increases pH value towards neutral.

16	D Acidic oxides (e.g. CO_2) react with alkalis Amphoteric oxides (e.g. ZnO) react with both acids and alkalis. Basic oxides (e.g. CuO) do not react with alkali.

17	B Insoluble base/carbonate + acid → filter off excess solid → evaporate filtrate → crystallise salt. • $CuSO_4$ can be made by reacting an insoluble copper(II) oxide/carbonate with dilute sulfuric acid. • Ammonium chloride is prepared by titration method. • Barium sulfate is insoluble; it forms via precipitation, not crystallisation. • Potassium chloride is prepared by titration method.

18	**B** Higher pressure → higher yield of NH_3; also increases reaction rate. Higher temperature increases reaction rate but reduces yield. Catalyst increases reaction rate only; no change to yield.

19	**A** Reaction of metal ions with $NH_3(aq)$ vs excess $NH_3(aq)$: Zn^{2+}: white $Zn(OH)_2$ ppt with few drops; dissolves in excess NH_3 to give colourless solution. Al^{3+}: white $Al(OH)_3$ ppt with few drops; does not dissolve in excess NH_3 (unlike in excess NaOH) After dissolving alloy in HCl you have $Zn^{2+}(aq)$ and $Al^{3+}(aq)$. Adding excess NH_3: Zn ppt dissolves, $Al(OH)_3$ remains→ white ppt observed.

20	**A** $Fe^{2+} + OH^- \rightarrow$ green $Fe(OH)_2(s)$. Fe^{3+} would give brown $Fe(OH)_3$ ppt. NH_4^+ + warm NaOH → NH_3 gas (alkaline, turns red litmus blue). Nitrate test (Al foil in warm alkali): forms NH_3→ turns red litmus blue. Green ppt ⇒ Fe^{2+}, not Fe^{3+}. Heating with NaOH produced no gas ⇒ no NH_4^+. After adding Al foil and warming, a gas formed that turned red litmus blue ⇒ NO_3^- present.

21	**A** Electrorefining of copper, electrolyte: $CuSO_4(aq)$. Anode (impure copper): $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ (anode loses mass). Cathode (pure copper): $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ (cathode gains mass). Electrolyte colour**:** remains blue (Cu^{2+} continually replenished at anode as it is removed at cathode).	
×	**B / D**	Solution does not become colourless; Cu^{2+} stays present.
×	**C**	Solution does not get increasingly blue overall; $[Cu^{2+}]$ is maintained.

22	**D** Cathode (reduction of O_2): $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$ ⇒ $[OH^-]$ increases → pH value increases**.** Anode (oxidation of H_2): $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$ ⇒ OH^- consumed → pH value decreases**.**

23	**A**
	Concept to recall: At inert anodes in dilute solutions, OH^- tends to be oxidised to O_2 unless the halide is concentrated and lower in the discharge series. Reasoning: Dilute NaCl**:** OH^- oxidised → O_2 (Cl_2 is favoured only when concentrated). Concentrated NaBr: Br^- oxidised → Br_2. Dilute Na_2SO_4: sulfate is hard to oxidise; OH^- oxidised → O_2**.**

24	**B**
	Concept to recall: Group number equals number of valence electrons in the atom. Reasoning: 1: 2,3 ⇒ Group 13. 2: 2,8,3 ⇒ Group 13. 3: $(2,8,8)^{3-}$ corresponds to P^{3-} (came from 2,8,5; Group 15 as an atom). Thus not same group as 1 & 2.

25	**A** Group 13 metals often form MCl_3 and their oxides are basic to neutralise acids.	
✓	**1**	$InCl_3$ is expected ($In^{3+} + 3Cl^-$).
✓	**2**	Its oxide neutralises nitric acid." Basic behaviour.
×	**3**	Its chloride forms coloured solutions." Most In(III) salts are colourless in solution.

26	**C** Group number → number of valence electrons**.** Period number → number of electron shells. Position across the Period/Group → whether oxides are acidic/basic/amphoteric, and reactivity trends. BUT the number of isotopes is determined by the nucleus (neutrons), and this does not follow a periodic pattern. You cannot look at an element's place in the table and know how many isotopes it has.	
×	**A**	Oxide nature → Predictable. Across Period 3 for example: Na_2O, MgO (basic); Al_2O_3 (amphoteric); SiO_2, P_4O_{10}, SO_3 (acidic).
×	**B**	Valence electrons→ Predictable. Group 1 all have 1 outer electron, Group 17 all have 7,
✓	**C**	Number of isotopes → Not predictable**.** Chlorine has 2 stable isotopes, carbon has 2 common stable isotopes, while fluorine has only 1. This pattern does not follow groups or periods.
×	**D**	Reactivity→ Predictable E.g. reactivity of alkali metals increases down Group 1; reactivity of halogens decreases down Group 17.

27	C	
	Density increases down Group 1. Melting point decreases down Group 1. Reactivity increases down Group 1 (lower ionisation energy). All Group 1 chlorides are soluble.	
×	**A**	Wrong. Rubidium is denser.
×	**B**	Wrong. Rubidium has a lower melting point.
✓	**C**	Rubidium is more reactive than K, so it reacts more explosively with water.
×	**D**	Both RbCl and KCl are soluble.

28	D	
	Physical state: fluorine and chlorine = gases, bromine = liquid, iodine = solid. Astatine, below iodine, is a solid at room temp. Reactivity decreases down the group. Sodium halides are ionic, not covalent. More reactive halogens (above) displace less reactive halogens (below).	
×	**A**	Wrong. Astatine is a solid.
×	**B**	Wrong. It is less reactive than iodine.
×	**C**	Wrong. Sodium–halogen compounds are ionic (e.g. NaCl).
✓	**D**	Correct. Chlorine, being more reactive, displaces At.

29	B
	Properties of transition metals • variable oxidation states. • forms coloured compounds. • catalysts • high melting points • A: Wrong. They have high melting points. B: Correct. They form ions with variable oxidation states hence, they participate in redox reactions. C: Wrong. Fe and Cu are not in the same group. D: Wrong. They form oxides readily.

30	C
	Argon is a noble gas: inert, does not react, prevents oxidation. Does not conduct electricity, nor form oxides.

31	A	
	Metals that are more reactive than carbon or hydrogen must be extracted by electrolysis.	
✓	**A**	Correct. More reactive than both, so electrolysis needed.
×	**B**	Wrong. If less reactive than carbon, it could be reduced by carbon.
×	**C**	Wrong. Metals below H can exist uncombined. But if a metal is less reactive than H, then hydrogen can reduce its oxide. But the question says the oxide cannot be reduced by H or C, so this contradicts.
×	**D**	Wrong. If it were between H and C, it could be reduced by H.

32	C
	A catalyst lowers activation energy (Ea). ΔH (enthalpy change) of reaction remains the same. Mass of catalyst remains unchanged. Thus the correct diagram is the one with lower forward Ea but same overall ΔH**.**

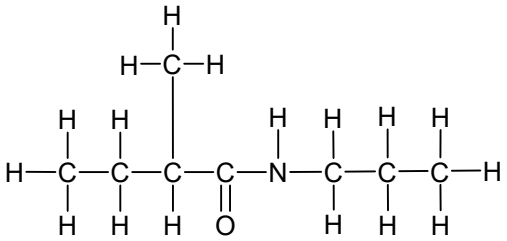
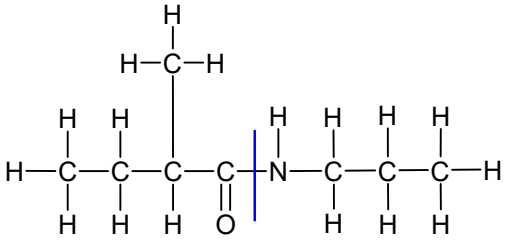
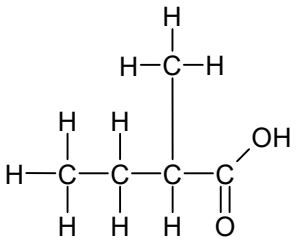
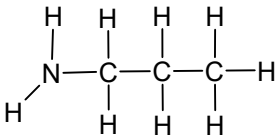
33	A
	Reaction: $2NO \rightarrow N_2 + O_2$, ΔH = –180 kJ Asked: $4NO \rightarrow 2N_2 + 2O_2$ Doubling stoichiometric coefficients doubles ΔH. ΔH = 2 × (–180) = –360 kJ.

34	A	
	Smaller hydrocarbons → weaker intermolecular forces → lower boiling point → condense higher up (cooler). Diesel has larger molecules, higher boiling points, condenses lower.	
✓	**A**	Petrol smaller molecules, weaker forces, condenses higher.
×	**B**	Flammability irrelevant to separation.
×	**C**	All hydrocarbons have similar covalent bonds; difference lies in intermolecular forces, not covalent bonds.
×	**D**	Larger molecules condense lower, not higher.

35	D
	Check each option for balance and conditions: A: C balance (10 C), but only 1 alkene repeated (C_2H_4) + 1 alkene (C_3H_6) + 1 alkane → not 2 different alkenes + extra**.** B: Carbons = 12 > 10 → unbalanced. C: Gives 2 alkenes + 1 alkane, but not 2 different alkenes. D: $C_{10}H_{22} \rightarrow H_2 + 2C_2H_4 + 2C_3H_6$ → Carbons: 10, Hydrogens: 22. Balanced. Two different alkenes present.

36	C
	Mr = (6×12) + (10×1) + (4×16) = 72 + 10 + 64 = 146. Hence contains 6 carbon atoms.

37	B
	Ethanoic acid: Molecular $C_2H_4O_2$, Empirical CH_2O → different. Ethyl ethanoate: Molecular $C_4H_8O_2$, Empirical C_2H_4O → different. Propane: Molecular C_3H_8, Empirical C_3H_8 (already simplest).

38	A
	   

39	B
	Total monomers = (10×116) + (10×146) = 2620. Polymer chain of 20 monomers has 19 amide bonds. Each bond formation eliminates 1 H_2O (Mr 18). So Mr = 2620 – (19×18) = 2620 – 342 = 2278.

40	D
	Clothing (polyester/nylon) ✓ Fishing line (nylon) ✓ Parachutes (nylon) ✓