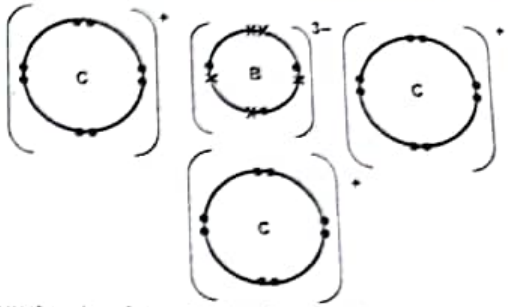
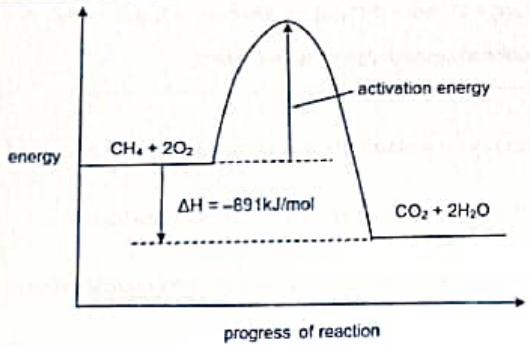
2022 Chemistry Preliminary Examinations

Mark Scheme (Paper 2)

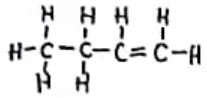
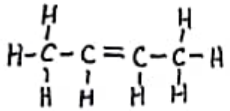
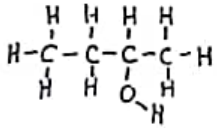
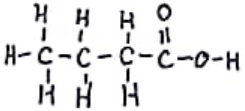
Question	Mark Scheme	Mark
A1(a)	He, H_2, O_2, Cl_2 (any two)	1
A1(b)	NH_3 and Cl_2	1
A1(c)	CO_2 and O_2	1
A1(d)	CH_4	1
A1(e)	CO	1
A2(a)(i)	Number of neutrons = 48 Nucleon number = 56 [1] Both correct	1
A2a(ii)	2 8 8 1	1
A2(a)(iii)	E^{2-} Accept O^{2-} as the assessment objective is to see if student know that E can form an anion with –2 charge.	1
A2(a)(iv)	A and E Both A and E are atoms that have the same number of protons but different number of neutrons [1] for correct identification of isotopes and explanation. No need 'atoms' since the question context has already stated. Accept: same proton number, atomic number (since these are scientific terms) Reject: neutron number (no such scientific term), nucleon number (need to break down what this term means and go back to the definition)	1
A2(b)(i)	B: nitrogen D: potassium F: iron	1
A2(b)(ii)	Highest melting point: iron (F) potassium (D) Lowest melting point: nitrogen (B) CAO. *No ecf b(i)*	1
A2(b)(iii)	B has weak intermolecular forces of attraction / weak forces of attraction between the molecules. Hence, less energy is absorbed to overcome the bonds F has strong electrostatic forces of attraction / metallic bonds between the cations and 'sea' of delocalised electrons. Hence, more energy is required to overcome the bonds [1] Correct types of bonds and particles [1] Energy comparison only awarded if bonds and particles are correct. *No ecf (b)(ii)*	1 1

Question	Mark Scheme	Mark
A2(c)	 [1] Correct number of electrons drawn for cation C^+ and anion B^{3-} [1] Correct charges and ratio of cations to anion (3:1)	2
A3(a)	Manganese has variable oxidation states, +2 in Mn^{2+}/$Mn(OH)_2$ and +3 in $Mn(OH)_3$. $MnSO_4$ acts as a catalyst as $MnSO_4$ in step 1 is regenerated in step 3	1 1
A3(b)	$2Mn(OH)_3(s) + 2I^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + I_2(aq) + 6H_2O(l)$ correct balanced equation (ignore state symbols)	1
A3(c)(i)	+2	1
A3(c)(ii)	I_2 is reduced as the oxidation of iodine decreases from 0 in I_2 to –1 in NaI. $Na_2S_2O_3$ is oxidised as the oxidation of sulfur increases from +2 in $Na_2S_2O_3$ to +2.5 in $Na_2S_4O_6$. *Ecf for oxidation state of sulfur in $Na_2S_2O_3$ only if the oxidation state is increased.*	1 1
A3(d)	Colour changes from blueish-black/blue-black to colourless *Reject: Blue or black only*	1

Question	Mark Scheme	Mark
A3(e)	Moles of $Na_2S_2O_3$ used = 0.0100 x (11.20/1000) = 0.000112 mol	1
	Moles of I_2 = 0.000112 / 2 = 0.0000560 mol Moles of $Mn(OH)_3$ = 2 x 0.0000560 = 0.000112 mol Moles of O_2 present = 0.000112 / 4 = 0.0000280 mol [1] *for showing appropriate mole ratio working to get correct moles of O_2*	1
	Concentration of O_2 = 0.0000280 ÷ (100/1000) = 0.000280 mol/dm^3 CAO	1
A4(a)(i)	Density = 16 / 24 = 0.667 g/dm^3 *Award for numerical answer only. Ignore units if missing.*	1
A4(a)(ii)	Energy per gram = 762 / 32 = 22.7 kJ/g *Award for numerical answer only. Ignore units if missing.*	1
A4(a)(iii)	Petrol is not a pure substance OR it consists of a mixture of hydrocarbons. Hence, there is no fixed enthalpy change of combustion.	1
A4(b)(i)	 Correct formulae of products. Ignore if equation is not balanced. [1] ΔH (with energy level) [1] activation energy [1]	1 1 1

Question	Mark Scheme	Mark
A4(b)(ii)	Methane has a higher percentage of carbon than methanol. For the same number of moles of fuel, methane requires more oxygen for complete combustion OR more likely to undergo incomplete combustion. Hence, methane is more likely to undergo incomplete combustion.	1 1
A4(c)	Complete combustion of hydrogen produces only water which is a non-pollutant. However, combustion of methane produces carbon dioxide which is a greenhouse gas that leads to global warming.	1 1
A4(d)(i)	ΔH = 3(410) + 360 + 463 – 2(436) – 1077 = 2053 – 1949 = +104 kJ/mol CAO, must include a positive sign, ignore missing units	1 1
A4(d)(ii)	Step 1 is endothermic OR Energy is absorbed when methanol is converted from a liquid to a gas. *OWTTE to mention energy change due to the change in physical states*	1
A4(d)(iii)	The carbon monoxide produced is toxic as it binds to haemoglobin / prevents the blood to transport oxygen and leads to breathlessness and eventually death. *OWTTE about the inability to transport oxygen* OR The methanol used is toxic as it can lead to headache, dizziness or loss of consciousness.	1
A5(a)(i)	C_5H_{10}	1
A5(a)(ii)	Condition: uv light $C_4H_8 + Cl_2 \longrightarrow C_4H_7Cl + HCl$ No need state symbols. Multiple chlorine-substituted product must come with corresponding HCl.	1 1
A5(b)(i)	C_4H_8	1

Question	Mark Scheme	Mark
A5(b)(ii)		

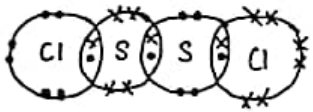
organic compound	structural formula	
W		1
X		1
Y		1
Z		1

Question	Mark Scheme	Mark
A5(d)	Let the mass of S be 100 g	

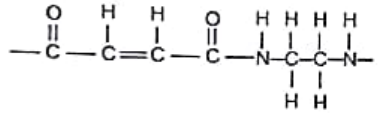
	C	H	O	Br		
Mass / g	100 – 68.7 = 31.3 g	5.9 g	10.5 g	52.3 g	includes assumption of mass above.	1
Mole /mol	31.3 / 12 = 2.61	5.9 /1 = 5.9	10.5 / 16 = 0.656	52.3 / 80 = 0.654	2 to 3 sf	1
Simplest mole ratio	4	9	1	1	No mark To be awarded in EF	

Empirical formula = C_4H_9BrO 1

B6(a)(i)	Electronegativity decreases down Group II elements As the atomic size increases, the attraction between the nucleus and valence electrons is weaker, making the atom less likely to attract electrons.	1 1
B6(a)(ii)	Any value between 0.82 to 0.98 (actual 0.93)	1
B6(b)	Helium, neon and argon have fully filled valence electron shells and they are unable to form bonds with other elements.	1 1
B6(c)	Σ of Al_2O_3 = 3.44 – 1.61 = 1.83 and Σ of $AlCl_3$ = 3.16 – 1.61 = 1.55 CAO Σ value of Al_2O_3 does not support. Al_2O_3 is an ionic compound but its Σ is less than 2.0 Σ value of $AlCl_3$ supports the bonding in $AlCl_3$. [no mark]	1 1

Question	Mark Scheme	Mark
B6(d)	Student 1 No. [No mark] For example, Σ value (H-F) / bond energy of H-F = 1.78/562 = 0.00317 and Σ value (H-Cl) / bond energy of H-Cl = 0.96/431 = 0.00223 do not give the same constant value. [1] Accept: Other examples with single covalent bonds. Student 2 From table 6.3, there is only one Σ value for CO bond and it cannot be used to predict the bond strengths of C-O, C=O or C≡O (cannot tell the difference between the type of bonds in CO and hence the strengths).	1 1
B6(e)(i)	Nitrogen is more electronegative than hydrogen and the bonding electrons should be closer to the nucleus of the nitrogen.	1
B6(e)(ii)	 [1] both sulfur atoms (Must be illustrated by 'dots' and 'crosses' to show how each atom shares the electron. Reject if only crosses or dots are shown.) [1] both chlorine atoms with each chlorine atom bonded to different sulfur atom.	 1 1
B7(a)	The electrodes and copper wires have free moving electrons [1] to conduct electricity whereas the electrolyte has free moving ions to conduct electricity. [1]	1 1
B7(b)	$Zn(s) + 2H^+(aq) \longrightarrow Zn^{2+}(aq) + H_2(g)$ Or $Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$ Accept: If no state symbols are written. Reject: If state symbols are written incorrectly.	1

Question	Mark Scheme	Mark
B7(c)(i)	$Ag^+(aq) + e^- \longrightarrow Ag(s)$ Reject: If no or wrong state symbols are written.	1
B7(c)(ii)	The pH of the electrolyte decreases. OH^- is preferentially discharged at graphite electrode 2 and resulting in a lower OH^- concentration or concentration of OH^- becomes lower than concentration of H^+.	1 1
B7(d)	Oxide ions are discharged to give oxygen gas at graphite electrode 2. After a long period of time, the oxygen gas produced reacts / oxidises graphite electrode 2 to become carbon dioxide gas Accept: equations written for the reactions at the electrode At graphite electrode 2: $2O^{2-}(l) \longrightarrow O_2(g) + 2e^-$ and $C(s) + O_2(g) \longrightarrow CO_2(g)$	1 1
Either B8(a)(i)	There is a higher concentration of hydrogen ions, H^+ in nitric acid than phosphoric acid. The frequency of effective collision between the hydrogen ions and metal in the alloy will be higher in nitric acid than phosphoric acid. Hence, the speed of reaction will be higher for nitric acid than phosphoric acid. [no mark]	1 1
B8(a)(ii)	18 ± 1 hours (± 5%) *Minus [1] for overall paper if no units.*	1
B8(b)(i)	$2CH_3COOH + Mg \longrightarrow (CH_3COO)_2Mg + H_2$	1
B8(b)(ii)	Add ethanoic acid in excess OR until no more effervescence is observed. Filter the mixture to obtain copper as the residue. Wash the residue with water to obtain pure copper.	1 1

Question	Mark Scheme	Mark
B8(c)(i)	Pass the gas through acidified $KMnO_4$.	1
	Purple acidified $KMnO_4$ decolourises.	1
B8(c)(i)		
	• Amide linkage clearly shown.	1
	• Correct number and type of atoms in polymer with the two ends of the polymer unbonded to any atoms. Bonding between atoms must be correct.	1
Or B8(a)(i)	$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$	1
B8(a)(ii)	Y, X, Z	1
	More reactive metal forms more thermally stable metal compounds.	1
	Since the rate of decomposition of ZCO_3 is the greatest followed by XCO_3 and YCO_3,	1
	Z is the least reactive metal followed by **X** and **Y** which is the most reactive metal. [no mark as this is awarded above]	
	[1] Identify the correct relationship between metal reactivity and metal compound stability.	
	[1] Use relationship above to link to data (i.e. rate of decomposition) given in the table.	
B8(b)(i)	This is a reversible reaction. [no mark]	
	When phosphorus reacts with bromine to form phosphorus tribromide, some phosphorus tribromide decomposes (breaks down, converted back) to give phosphorus and bromine.	1
	[1] awarded for the understanding of reactants converted to products and back with relevant context (i.e. identities of reactants of products stated).	
B8(b)(ii)	Chlorine is <u>more reactive</u> than bromine.	1
	The <u>rate of reaction</u> of phosphorus with chlorine should be <u>higher</u> than that with bromine.	1

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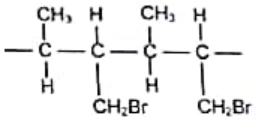
B8(c)(i)		1
	Note: No need to show displayed formula. All bonds must be correctly bonded e.g. C is bonded directly to C in $-CH_2Br$.	
B8(c)(ii)	M_r of $CH_3CHCHCH_2Br$ monomer = 4(12) + 7 + 80 = 135	
	No. of monomer present in polymer = 33750 ÷ 135 = 250 CAO	1
	Since each monomer has 4 carbon atoms, no. of carbon atoms in polymer = 250 x 4 = <u>1000</u> CAO	1