2023 CHS S4 Prelim Mark Scheme

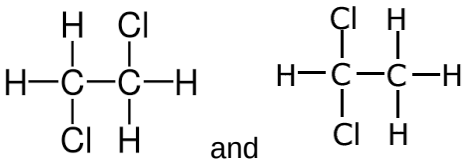
Paper 1

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

Paper 2 Section A

<table>
<tr><td>A1</td><td>(a)</td><td>
<table>
<tr><th></th><th></th><th>Put a tick (✓) if
a redox reaction would occur.</th></tr>
<tr><td>(i)</td><td>a copper strip added to lead(II) nitrate solution</td><td></td></tr>
<tr><td>(ii)</td><td>aqueous chlorine added to potassium iodide solution</td><td>✓</td></tr>
<tr><td>(iii)</td><td>hydrogen gas passed over heated copper(II) oxide</td><td>✓</td></tr>
<tr><td>(iv)</td><td>potassium nitrate solution warmed with sodium hydroxide solution</td><td></td></tr>
</table>
4 correct – 3m , 3 correct – 2m, 2 correct – 1m
</td><td></td></tr>
<tr><td></td><td>(b)</td><td>Difference: Reaction rate is slower when used with aqueous bromine OWTTE;

Explain: Chlorine is more reactive than bromine/ gains electrons more readily (and displaces iodine from iodide solution faster); OWTTE</td><td></td></tr>
<tr><td>A2</td><td>(a)</td><td>As the number of Cl <u>atoms</u> in the compound increases, the boiling point increases.

A: has more Cl atom substituted/ less H atoms
R: increasing M_r/ molecular size</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) C_2H_6</td><td></td></tr>
<tr><td></td><td></td><td>(ii) $C_2H_4Cl_2$</td><td></td></tr>
<tr><td></td><td></td><td>(iiii) 5</td><td></td></tr>
<tr><td></td><td>(c)</td><td> 
and

1m for each correct structure</td><td></td></tr>
</table>

<table>
<tr><td>A3</td><td>(a)</td><td>Carbon dioxide = C;

phosphorus pentoxide = B;

both has simple molecular/ covalent structure;

where a small amount of energy is needed to overcome weak intermolecular forces;

phosphorus pentoxide is a <u>larger</u> molecule with <u>stronger intermolecular forces</u></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) 1 similarity (1m) + 1 difference (1m)

Similarity:
both has giant molecular/ covalent structure;

both consists of only the same type of atoms

difference:

<table>
<tr><td></td><td>Silicon</td><td>Graphite</td></tr>
<tr><td>Difference 1</td><td>Only has strong covalent bonds between atoms</td><td>Has both strong covalent bonds and weak intermolecular forces</td></tr>
<tr><td>Difference 2</td><td>Not layered</td><td>Layered</td></tr>
<tr><td>Difference 3</td><td>Tetrahedral structure or 1 atom bonded to 4 other atoms</td><td>Hexagonal structure or 1 atom bonded to 3 other atoms</td></tr>
</table>
</td><td></td></tr>
<tr><td></td><td></td><td>(ii) No. +
A semiconductor needs to have presence of mobile charged carriers such as ions or electrons;

All 4 valence electrons are used in bonding (and absence of ions/ contains only atoms)</td><td></td></tr>
<tr><td>A4</td><td>(a)</td><td>(i) removes carbon dioxide from atmosphere + hence regulating amount of carbon dioxide OWTTE</td><td></td></tr>
<tr><td></td><td></td><td>(ii) $2NO + 2CO \rightarrow 2CO_2 + N_2$;
$2CO + O_2 \rightarrow 2CO_2$
A: $2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$
A: $2NO_2 + 4CO \rightarrow 4CO_2 + N_2$;
R: formation of sulfur dioxide (fuel does not contain S)

Still releases large amount of carbon dioxide into the atmosphere + explain how carbon dioxide causes environmental problems (see e.g. below)

Global warming/ Melting of ice caps/ rise in sea levels/ flooding in low-lying areas etc</td><td></td></tr>
</table>

<table>
<tr><td></td><td>(b)</td><td>(i) The set-up using light will produce gas X but the set-up without light will not produce any gas X (or oxygen gas);

Or In the absence of light, carbon dioxide is produced while in the presence of light, gas X / oxygen is produced (+ CO_2)

I: if students discussed observations such as presence of effervescence
R: More gas given off for set-up with light than set-up without light</td><td></td></tr>
<tr><td></td><td></td><td>(ii) To determine if a reaction is endothermic or exothermic, we have to consider the difference in both energy taken in / absorbed and energy released / given off; OWTTE

A: Light energy used for activation energy

A: if explain in terms of bond break/ form</td><td></td></tr>
<tr><td>A5</td><td>(a)</td><td>$C_3H_7OH + 2[O] \rightarrow C_2H_5COOH + H_2O$ or

$C_3H_8O + 2[O] \rightarrow C_3H_6O_2 + H_2O$</td><td></td></tr>
<tr><td></td><td>(b)
(i)</td><td>
<table>
<tr><td></td><td>C</td><td>H</td><td>O</td></tr>
<tr><td>%</td><td>64.6</td><td>10.8</td><td>24.6</td></tr>
<tr><td>A_r</td><td>12</td><td>1</td><td>16</td></tr>
<tr><td>No. of moles</td><td>$\frac{64.6}{12} = 5.383$</td><td>$\frac{10.8}{1} = 10.8$</td><td>$\frac{24.6}{16} = 1.537$</td></tr>
<tr><td>Mole ratio</td><td>$\frac{5.383}{1.537} = 3.5$</td><td>$\frac{10.8}{1.537} = 7$</td><td>$\frac{1.537}{1.537} = 1$</td></tr>
<tr><td>Simplest ratio</td><td>7</td><td>14</td><td>2</td></tr>
</table>

1m for calculating no. of moles

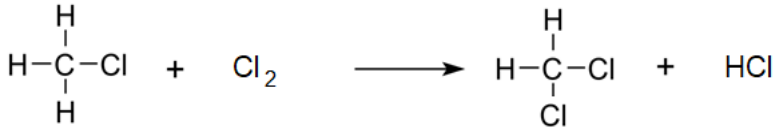
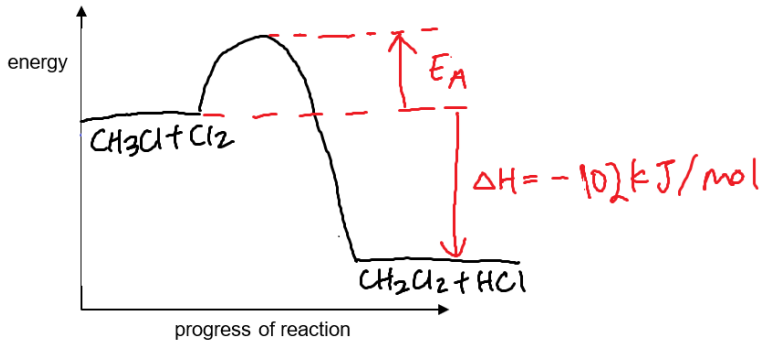
Empirical formula of R = $C_7H_{14}O_2$ [1]</td><td></td></tr>
<tr><td></td><td>(ii)</td><td>Butyl propanoate</td><td></td></tr>
<tr><td></td><td>(c)</td><td>(i) any suitable metal carbonate or ammonium carbonate</td><td></td></tr>
<tr><td></td><td></td><td>(ii) corresponding metal/ ammonium propanoate

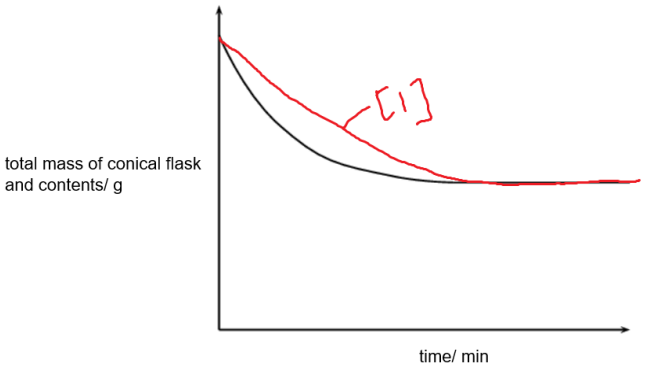
E.g. NaC_2H_5COO or C_2H_5COONa or

$Ca(C_2H_5COO)_2$ or $(C_2H_5COO)_2Ca$

A: molecular formula e.g. $NaC_3H_5O_2$</td><td></td></tr>
<tr><td>A6</td><td>(a)</td><td>Comparison of energy + recognise bond forming releases energy and bond breaking absorbs energy ; [1]

Identify forming bonds in correct products + breaking bonds in correct reactants; [1]</td><td></td></tr>
</table>

		Suggested answer: More energy is given off/ released when forming bonds in HC*l* / hydrogen chloride and CH_3Cl/ chloromethane than taken in/ absorbed when breaking bonds in methane/ CH_4 and chlorine/ Cl_2.	
	(b)	(i) 	
		(ii) −102 kJ/ mol; [1] Both require breaking 1 mole of C–H and 1 mole of C*l*–C*l* bonds in reactants and both form 1 mole of C–C*l* and 1 mole of H–C*l* bonds [1] A: 1 C-H bond etc instead of saying 1 mole	
		(iii)  • the reactants of the reaction • the products of the reaction • the energy profile and the enthalpy change of reaction, Δ*H*. 1m • activation energy, E_a 1m	
A7	(a)	(i) electrode 1: $4OH^-$ (aq) → $2H_2O$(l) + O_2 (g) + $4e^-$; Electrode 2: $2H^+$ (aq) + $2e^-$ → H_2(g)	
		(ii) filter paper around electrode 1 changes from purple to red; [1] Filter paper around electrode 2 changes from purple to blue; [1] Reference to difference in concentration of H^+ and OH^- + determine acidic/ alkaline; [1] Suggested answer: concentration of OH^- < concentration of H^+, so solution around electrode 1 is acidic and turns litmus solution red	

		+ concentration of H^+ < concentration of OH^-, so solution around electrode 2 is alkaline and turns litmus solution blue	
A7	(b)	(i) barium nitrate is soluble in water (A: aqueous solution) [1]	
		(ii) A white precipitate was observed on the filter paper. [1]	
A8	(a)	(i) 	
		(ii) chlorine gas is soluble in water + so the mass loss is less than expected [1]	
		(iii) The rate of reaction is not constant throughout the reaction OWTTE [1]	
	(b)	Conclusion 1: increase the total surface area of MnO_2 [1] Conclusion 2: MnO_2 is a catalyst + no change in the amount/ mole of limiting reactant / no change in yield. [1]	
Section B			
B9	(a)	Hydrogen ion has 0 electrons, 0 neutrons and 1 proton only [1]	
	(b)	(i) $H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ Conc. of H^+ ions = 0.025 mol/ dm^3 × 2 = 0.05 mol/ dm^3 [M1] pH = 1.3 (taken from table 9.2) [A1] A: 1.30 (3sf)	

(ii) pH = $\frac{k}{[Concentration\ of\ H+]}$; [1] (A: if embedded in working)

students use any 2 sets of data to find 2 k values [1]

conclude that since the two k values are different, students claim is false [1]

	Data 1	Data 2	Data 3	Data 4
pH	1.3	1.6	1.9	2.0
	1.3 = $\frac{k}{0.05}$	1.6 = $\frac{k}{0.025}$	1.9 = $\frac{k}{0.0125}$	2.0 = $\frac{k}{0.010}$
K value	K = 0.065	K = 0.04	K =0.02375	K = 0.02

(c) (i) when solution is pH 3,

Thymol blue appears yellow +
Methyl red appears red +
Bromothymol blue appears yellow +
Phenolphthalein appears colourless

1m

Overall is mixture of yellow and red which makes it orange ; [1]

(ii)

Criteria	Claim	Evidence + reasoning
has a narrow pH range in which it changes colour	Does not fulfil	pH range in which it changes colour is from 1.2 to 10.5 (wide range; typically the range is about 1.6 to 2.5)
has a distinctive colour at lower pH and a different colour at higher pH	Does not fulfil	Lower pH can have colours such as red and orange and higher pH can have colours such as blue or purple (state more than 1 colour for lower pH and more than 1 colour for higher pH) / More than 2 colours or has multiple colours at lower pH / higher pH
changes colour only once during the titration	Does not fulfil	Can change from orange to yellow (at pH 6) to green (at pH 7) (quote at least 2 colour change) / Changes colour twice before equivalence point
pH range of indicator in which indicator changes colour to fall within the definite 'step' of the reaction	Does not fulfil	pH range of indicator which is from pH 1.2 to 10.5 and pH change of the 'step' is between pH 3 to 11

<table>
<tr><td>B10</td><td>(a)</td><td>Catalytic properties;

Form coloured compounds;

High melting/boiling points;

High density

Any 2</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)<table><tr><th>chemical formula</th><th>oxidation state of J</th></tr><tr><td>J_2F_4</td><td>+2</td></tr><tr><td>JCl_3</td><td>+3</td></tr><tr><td>JH_3</td><td>−3</td></tr></table>All 3 correct – 2m, 1 or 2 correct – 1m</td><td></td></tr>
<tr><td></td><td></td><td>(ii) evidence: has negative oxidation state of −3 ; [1]

Reasoning: transition elements are metals which only lose electrons + hence only can have positive oxidation states [1]
Or
Evidence: all three compounds of J show sharing of electrons; [1]
A: forms molecules

Reasoning: covalent bonding occurs typically between two non-metals [1]

or
Evidence: J has 5 valence electrons. [1]

Reasoning: elements with 5 or more valence electrons are non-metals. [1]</td><td></td></tr>
<tr><td>Either</td><td></td><td></td><td></td></tr>
<tr><td>B11</td><td>(a)</td><td>Limestone: remove acidic impurities (such as silicon dioxide); [1]

Coke: reducing agent/ forms carbon monoxide which is the main reducing agent [1]</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i) $C + O_2 \rightarrow CO_2$ [1]</td><td></td></tr>
<tr><td></td><td></td><td>(ii) formation of carbon dioxide is an exothermic reaction / gives off heat [1]</td><td></td></tr>
<tr><td></td><td></td><td>(iii) any 3 points for 3m

additional atoms with smaller atomic size to represent carbon atoms;

all particles to be slightly further apart/ have small spaces in between</td><td></td></tr>
</table>

		distance is slightly further than liquid state (because of expansion); all particles to be disorderly arranged;	
	(c)	(i) 2 points - 1m, all 3 points - 2m both Fe and Pb loses oxygen atoms Fe_2O_3 loses oxygen to become Fe PbO loses oxygen to become Pb	
		(ii) Does not release toxic CO into the atmosphere; [1] or Using CO gas will ensure better contact with reactant compared to C solid [1]	
OR			
B11	(a)	Carbonate 2; [1] There is no loss in mass/ did not form CO_2 gas + did not decompose at all/ OWTTE [1]	
	(b)	Mass lost = mass of carbon dioxide formed = 2 – 1.30 = 0.70 g [M1] No. of moles of carbon dioxide = $\frac{0.70}{44}$ = 0.01590 mol No. of moles of metal carbonate = 0.01590 mol M_r of metal carbonate = $\frac{2.00}{0.01590}$ = 125.78 [M1] A_r of metal = 125.78 – 12 – 48 = 65.78 Carbonate 3 is zinc carbonate/ $ZnCO_3$ [A1]	
	(c)	Same mass of carbonate contains different mole of each carbonate due to different M_r/ molar mass; [1] Hence each carbonate gives off different mole of carbon dioxide gas which equates to different mass of carbon dioxide gas evolved (since ratio of mole of metal carbonate to mole of carbon dioxide is 1:1) [1]	
	(d)	(i) $2Ag_2CO_3 \rightarrow 4Ag + 2CO_2 + O_2$	
		(ii) just above or below Ag/ similar to Ag / below Cu; Compare thermal stability of copper(II) oxide with mercury oxide; E.g. Copper(II) oxide is thermally stable, does not decompose further to form Cu metal. Copper is hence more reactive than mercury.	