2025 Preliminary Examination H1 Chemistry (8873)
Suggested Solutions

Paper 1

1	D		11	B		21	C
2	A		12	D		22	A
3	C		13	B		23	D
4	B		14	D		24	B
5	B		15	A		25	A
6	C		16	B		26	D
7	C		17	C		27	B
8	A		18	B		28	C
9	C		19	B		29	D
10	B		20	D		30	C

Paper 2 Section A

1(a)(i)	E and F have the same number of protons but different number of neutrons. [1] no partial credit
(ii)	G has **7** electrons pairs [1]
(iii)	A and C [1]
(iv)	C and D have the **same number of protons**, but C has **one more quantum shell** than D. Hence, C has a **larger shielding effect** and smaller effective nuclear charge than D, resulting in weaker attraction between the nucleus and outermost electrons. [1] same no. of proton + larger shielding effect. Award 0.5 mark if only say 'smaller effective charge' [1] C has one more quantum shell
(v)	B and G are deflected to the **negative** plate as they are **cations**. [0.5] E is deflected to the **positive** plate as it is an **anion**. [0.5] 0.5 mark for 'opposite directions' only angle of deflection α $\frac{\text{charge}}{\text{mass}}$ angle of E **equals** angle of G as they have the **same charges and masses** [0.5] angle of B is **smaller** than angle of E (or G) as **B has a greater mass** [0.5] • Directions + reasons in terms of identity or charges • Relative angle + reasons in terms of charges and masses
(b)(i)	A **large difference** in electronegativity between the element and chlorine results in (transfer of electrons and) **ionic bonding**, while a **small difference** results in (sharing of electrons and) **covalent bonding**. [0.5] explanation for ionic bonding [0.5] explanation for covalent bonding
(ii)	$NaCl(s) \rightarrow Na^{+}(aq) + Cl^{-}(aq)$ [1] $PCl_5(s) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(aq)$ [1] state symbols not required pH of **mixture** = 1 [1] award 0.5 mark for correct pH of separate solutions

2(a)	It states that if the **conditions** of a system in equilibrium are **changed**, the position of equilibrium will **shift** in a way to **reduce** that change. [1] no partial credit for definition
(b)(i)	From Fig 2.1, when **temperature increases, yield increases** which implies position of equilibrium shifted **right**. Hence, **forward** reaction is **endothermic** as it **absorbs** the **additional heat** to offset the increase in temperature. [1] correct shift in p.o.e. [0.5] endothermic [0.5] reasons in terms of heat
(ii)	From Fig 2.1, when **pressure increases, yield increases** which implies position of equilibrium shifted **right**. Hence, **forward** reaction results in a **decrease** in total number of **gas molecules** as this will offset the increase in pressure. [1] correct shift in p.o.e. [1] decrease in total no. of gas molecules
(c)(i)	$K_c = \frac{[H_2][CO]}{[H_2O]}$ [1]

(ii)

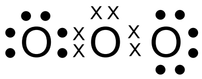
	$H_2O(g)$	+	C(s)	$\rightleftharpoons$	$H_2(g)$	+	CO(g)
initial / mol	2.0				0		0
change / mol	-0.3				+0.3		+0.3
eqm / mol	**1.7**				0.3		**0.3**

[1] correct eqm amount of CO and H_2O

$K_c = \frac{0.3 \times 0.3}{1.7}$ = **0.0529** mol dm^{-3} [1] ecf from eqm amount, correct s.f.

3(a)(i)	Trichlorofluoromethane [1]
(ii)	Freon-14 [1]
(b)	According to VSEPR theory, to **minimise electronic repulsion**, electron pairs (or groups) will arrange themselves **as far apart as possible**. Since there are **4 bond pairs** around C atom, Freon-11 has a **tetrahedral** shape. [0.5] correct shape [0.5] correct number of bond pairs [1] correct explanation using VSEPR
(c)	Freon-12 is a **polar** molecule. [0.5] C-F bond and C-C*l* bond have **different polarities** (as electronegativity of C < C*l* < F). Hence, the individual **dipoles do not cancel off** (or net dipole moment is not zero) as the molecule has a tetrahedral shape. [0.5] correct explanation in terms of bond polarities and net dipole

(d)(i)



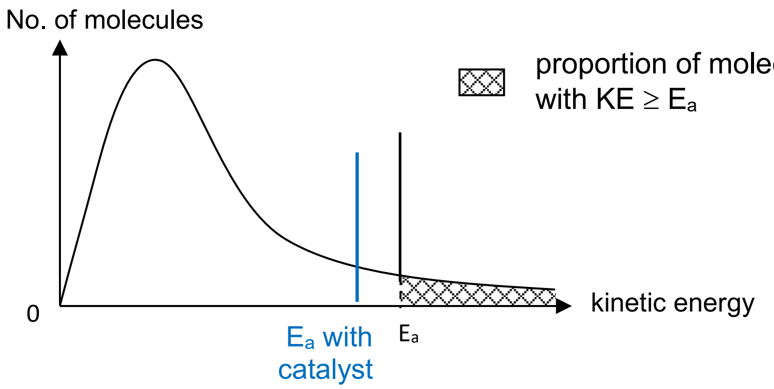
[1] use different symbols for adjacent atoms

(ii) C-F bond: 485 kJ mol^{-1}
C-C*l* bond: 340 kJ mol^{-1} [0.5] quote both values

C-C*l* bond is much **weaker** and **breaks more easily**.
or
C-F bond is much **stronger** and **does not break easily**. [0.5]

(iii) $2O_3 \rightarrow 3O_2$ [1]

(iv)

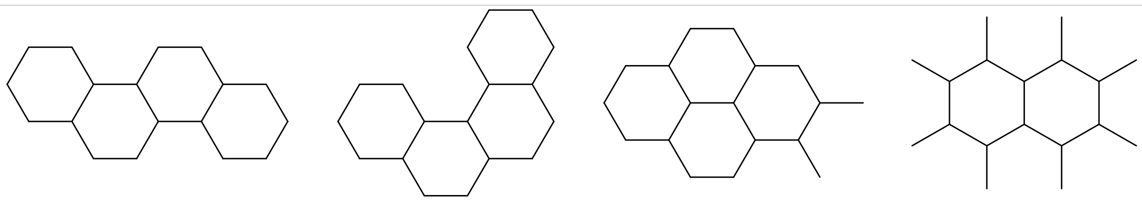


[1] correct diagram; deduct 0.5 mark if incomplete labels / curve did not start from origin

Chlorine atoms provide an alternative reaction pathway with a lower activation energy, **increasing** the **fraction** of particles with **energy greater than or equal to lower E_a**. [0.5]

Hence, the **frequency** of **effective** collisions **increases** and rate increases. [0.5]

(e)(i)



[1] Draw **only** 18 carbon atoms and at least two complete hexagonal rings

(ii) The **π electrons** in 3D graphene can **move** through each layer. [1]
or
The **delocalised electrons** in 3D graphene can **move** through each layer. [1]

(iii) lattice energy $\alpha \ \frac{q_+ \times q_-}{r_+ + r_-}$

F^- and Cl^- ions have the same charge but **F^- ion** has a **smaller radius**. [0.5]
Lattice energy of MgF_2 has a larger magnitude (or is more exothermic) so **more energy** [0.5] is needed to overcome the **stronger ionic bonds between Mg^{2+} and F^- ions**. [0.5]

MgF_2 has a higher melting point. [0.5]

4(a) Weak Brønsted-Lowry base is a **proton acceptor** that **dissociates partially** in water.

[1] no partial credit for definition

(b)(i) $nHCl = 0.10 \times \frac{38}{1000}$ [0.5]

$= 0.0038$ mol $= nCH_3NH_2$

$[CH_3NH_2] = \frac{0.0038}{25} \times 1000 =$ **0.152 mol dm^{-3}** [0.5] ecf from nCH_3NH_2 correct units, s.f.

(ii) CH_3NH_2 and $CH_3NH_3^+$ [0.5] each correct species

(iii) Since the two species are a conjugate-acid base pair, the solution is a **buffer**. [0.5]

When HC*l* is added, position of **equilibrium** $CH_3NH_2 + H^+ \rightleftharpoons CH_3NH_3^+$ **shifts right** to produce $CH_3NH_3^+$. [0.5]

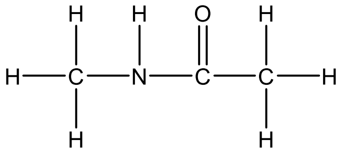
As the solution contains relatively **large amounts of both species**, $[CH_3NH_2]$ and $[CH_3NH_3^+]$ remain almost constant, hence $[H^+]$ and **pH remain almost constant**, and the slope only changes gradually.

[0.5] large amount / conc of base & conjugate acid or small amount of H^+ added (WTTE)
[0.5] pH remains almost constant

(iv) $CH_3NH_3^+ + OH^- \rightarrow CH_3NH_2 + H_2O$ [1] X $\rightleftharpoons$

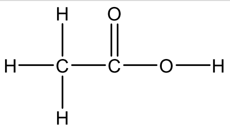
(c)(i) Condensation [1]

(ii)



[1] deduct 0.5 mark if not **displayed** formula

(d)(i)



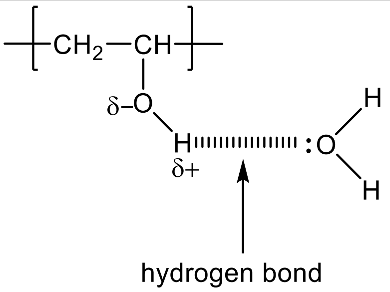
$+ 2\ O{=}O \rightarrow 2\ O{=}C{=}O + 2\ H{-}O{-}H$

	broken	formed	
C–C	350	4(805)	C=O
C–H	3(410)	4(460)	O–H
C=O	740		
C–O	360		
O–H	460		
O=O	2(496)		
ΔH_c =	4132	– 5060	= **–928 kJ mol^{-1}** correct sign, units, s.f.
	endo	exo	

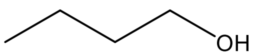
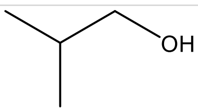
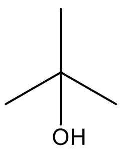
[0.5] correct BE of bonds broken [0.5] correct number of each bond
[0.5] correct BE of bonds formed [0.5] correct number of each bond
[1] correct ΔH_c (bonds broken - bonds formed) ECF

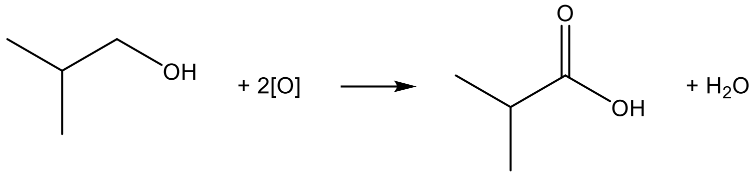
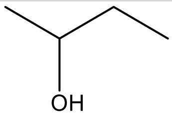
(ii) **Ethanoic acid and water exist as liquid,** but they are in the **gaseous state** in the calculation **using bond energies**. [1]

Hence, the calculated enthalpy change is different from the value quoted.

5(a)(i)	HDPE has **linear** polymer **chains** with **minimal branching** [0.5]. The chains can **pack closely** [0.5] together resulting in higher density.
(ii)	LDPE has **highly branched** [0.5] polymer chains that prevent close packing, resulting in **weaker dispersion forces between** the polymer **chains**. [1] Hence, **less energy** [0.5] is needed to overcome these forces during melting.
(iii)	The **C-C and C-H bonds are strong** [0.5] **and non-polar** [0.5] so the polymer is resistant to microbial attack.
(iv)	LDPE can **jam the sorting machine** as they are **soft and flexible**. [1] accept other reasons related to properties of LDPE
(v)	volume of pellet = 50 cm x 40 cm x 2 cm = 4000 cm^3 [0.5] mass of flakes needed = 0.95 x 4000 = 3800 g [0.5] ecf number of milk bottles needed = 3800 / 70 = 54.3 = **54** [1] ecf
(b)(i)	PVC is water-resistant [1]
(ii)	$–CH_2CHCl– + \frac{5}{2}O_2 \rightarrow 2CO_2 + H_2O + HCl$ [1]
(iii)	NaOH [1] accept other basic oxide or hydroxide e.g. $Mg(OH)_2$, $Ca(OH)_2$, $Al(OH)_3$
(c)(i)	 [1] dipole across O-H bond + lone pair on O atom [1] label hydrogen bonding; award 0.5 m if label is omitted but mentioned in explanation Accept H-bonding between H atom of H_2O and O atom of -OH group on PVA PVA has **many –OH groups** [0.5] which form hydrogen bonding with water molecules. Hence, PVA is **water-soluble** / dissolves in water [0.5], allowing the detergent to be released during washing.
(ii)	Moisture from humid air or wet hands could dissolve the PVA casing prematurely. [1] WTTE
(iii)	PVA is biodegradable / breaks down naturally hence **plastic waste is reduced** compared to non-biodegradable HDPE bottles. [1] appropriate environmental advantage

Paper 2 Section B

6(a)(i)	**Potassium** has a greater reactivity. [0.5] Potassium has **more quantum shells** than sodium, so the attraction between the valence electron and the nucleus is weaker. Hence, potassium **loses the valence electron more easily** and is a stronger **reducing agent**. [0.5] Identify the role of metal Explain in terms of electron shell [0.5] and ease of losing outer shell electrons [0.5]
(ii)	Bubbles / effervescence (of hydrogen gas) stops. [1]
(iii)	pOH = 14 – 13.6 = 0.4 [MOH] = $[OH^-]$ = $10^{-0.4}$ = **0.398 mol dm^{-3}** [1] correct units, s.f.
(iv)	nMOH formed = $0.398 \times \frac{100}{1000}$ [0.5] = 0.0398 mol = nM in 1.0 g A_r of M = $\frac{1.0}{0.0398}$ = 25.1 [0.5] no units, 1 d.p. M is **sodium**. [1]
(b)(i)	The **heat evolved** when **1 mole of water** is formed from an **acid-base** reaction at **298 K and 1 bar**. [1] no partial credit for definition
(ii)	nKOH = $1.0 \times \frac{50}{1000}$ = 0.05 mol nHC*l* = $2.0 \times \frac{50}{1000}$ = 0.10 mol ∴ nH_2O formed = 0.05 mol [1] $\Delta H_{neut} = -\frac{q}{nH2O} = -\frac{(50+50)\times 4.18\times 6.5}{0.05}$ [1] correct substitution into q = mcΔT = – 54340 J mol^{-1} = **– 54.3 kJ mol^{-1}** [1] correct answer correct sign, units (kJ mol^{-1}), s.f. (deduct 0.5 m)
(iii)	[1] Draw two straight lines, extend to t = 2.0 min ΔT_{max} = 36 – 29.2 = **6.8** °C [1] Read $T_{initial}$ and $T_{highest}$ to ½ small sq + correct subtraction
(iv)	The graph in method 2 **accounts for heat loss** to the surroundings. [1] WTTE
(c)(i)	primary  or  tertiary  [1] + [1]

(ii)	To each alcohol, add $K_2Cr_2O_7$ (or $KMnO_4$), dilute H_sSO_4 and heat. [1] Primary alcohol - **orange** $K_2Cr_2O_7$ turns **green** (or purple $KMnO_4$ turns colourless) [0.5] Tertiary alcohol - $K_2Cr_2O_7$ **remains orange** ($KMnO_4$ remains purple) [0.5] $CH_3CH_2CH_2\mathbf{CH_2OH} + 2[O] \rightarrow CH_3CH_2CH_2\mathbf{CO_2H} + H_2O$ or  [1] balanced eqn, correct product ✗ molecular formulae e.g. $C_4H_{10}O + 2[O] \rightarrow C_4H_8O_2 + H_2O$
(iii)	concentrated H_2SO_4, heat [1]
(iv)	 [1] deduct 0.5 mark if not **skeletal** formula

7(a)(i)	Br_2 acts as **oxidising agent**. [0.5] **H_2S is oxidised** by Br_2. Oxidation number of S **increases** from **-2 to 0**. [0.5] Accept: **Br_2 is reduced** by H_2S. Oxidation number of Br **decreases** from **0 to -1**.
(ii)	**Br_2** has a greater reactivity. [1] Bromine has **fewer quantum shells** than iodine, so the attraction between the **incoming electron** and the nucleus is stronger. Hence, bromine **gains electron more easily** and is a stronger oxidising agent. Explain in terms of electron shell [0.5] and ease of gaining electron [0.5]
(b)(i)	Down Group 17, the **number of electrons increases** [0.5] hence the electron cloud is more easily polarised. **More energy** [0.5] is needed to overcome the **stronger dispersion forces between the molecules**. [1] Hence, melting point increases.
(ii)	Br_2 is a **non-polar** [0.5] molecule so there are **only dispersion forces** (or id-id) **between** the molecules. [0.5] IC*l* is a **polar** [0.5] molecule (as C*l* is more electronegative than I) so there are **dispersion forces and permanent dipole-permanent dipole** (pd-pd) attractions **between** the molecules. [0.5] The **strength of dispersion forces is similar** as Br_2 and IC*l* molecules have the **same number of electrons** (or electron clouds are of similar sizes). [0.5] Overall, **inter**molecular forces between IC*l* will be **stronger** since there are dispersion forces and pd-pd attractions. [0.5]

(c)(i) The order of reaction with respect to a reactant is the **power on its concentration** term in the **experimentally** determined **rate equation**.

[1] no partial credit for definition

X Define overall order of reaction

(ii) Let rate = $k\,[H_2O_2]^a\,[I^-]^b\,[H^+]^c$

$$\frac{\text{rate}_4}{\text{rate}_2} = \frac{2}{1} = \frac{k \times 10^a 10^b 10^c}{k \times 5^a 10^b 10^c} \Rightarrow \frac{2}{1} = \frac{10^a}{5^a} \Rightarrow \text{order w.r.t. } [H_2O_2] = a = 1 \quad [1]$$

$$\frac{\text{rate}_3}{\text{rate}_2} = \frac{1.5}{1} = \frac{15^b}{10^b} \qquad \Rightarrow \text{order w.r.t. } [I^-] = b = 1 \quad [1]$$

$$\frac{\text{rate}_1}{\text{rate}_2} = \frac{3}{1} = \frac{15(5^c)}{5(10^c)} \qquad \Rightarrow 1 = 0.5^c \Rightarrow \text{order w.r.t. } [H^+] = c = 0 \quad [1]$$

Deduct 1 mark for missing / incomplete working

(iii) rate = $k\,[H_2O_2]\,[I^-]$

units of $k = \frac{\text{mol dm}^{-3}\ \text{s}^{-1}}{(\text{mol dm}^{-3})^2}$ = **mol^{-1} dm^3 s^{-1}** [1] Deduct 0.5 m if working is not shown

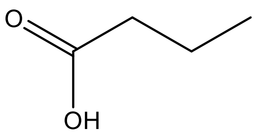
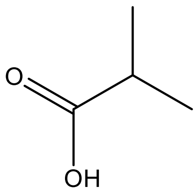
(iv) Colourless solution turns yellow. [1]

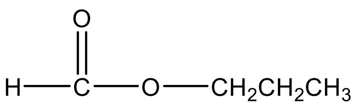
(d)(i) Aldehyde [0.5], **secondary** alcohol [0.5]

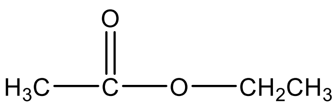
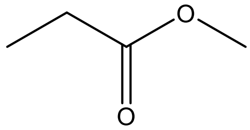
(ii) 13 σ bonds [0.5] 1 π bond [0.5]

(iii)

information	deduction
Y undergoes **acid-base reaction** with Na_2CO_3 [0.5]	Y contains **$-CO_2H$** group [0.5]
Z undergoes **hydrolysis** with hot NaOH [0.5]	Z contains **ester** group [0.5]

Y  or  [1]

Z 

or  or  [1]