Practice Paper 1D

Section A

1	D	**6**	B	**11**	B
2	A	**7**	C	**12**	A
3	C	**8**	C	**13**	C
4	D	**9**	C	**14**	B
5	A	**10**	A	**15**	D

Section B

16 a) Enthalpy change when one mole of a substance is burned completely in oxygen ✓
Under standard conditions ✓

b) $\frac{\text{Mass}}{M_r} = \frac{0.23}{72} = 3.19 \times 10^{-3}$ ✓

c) $Q = mc\Delta T$
$Q = 40 \times 4.18 \times 42$ ✓
$Q = 7022\ \text{J}$
$Q = \frac{\Delta H}{n \times 1000} = \frac{7022}{3.19 \times 10^{-3} \times 1000}$ ✓
$\Delta H = -2.20 \times 10^3\ \text{kJ mol}^{-1}$ ✓ (Must have minus sign for this mark, as T increases)

d) $\Delta H = n \times \Delta H_{vap}(H_2O) + \Delta H^{\circ}_f\,(\text{products}) - \Delta H^{\circ}_f\,(\text{reactants})$
$C_4H_8O + 5.5O_2 \rightarrow 4H_2O + 4CO_2$ ✓
$\Delta H = 4 \times \Delta H_{vap}(H_2O) + 4 \times \Delta H^{\circ}_f(CO_2) + 4 \times \Delta H^{\circ}_f(H_2O) - \Delta H^{\circ}_f(C_4H_8O)$ ✓ (can be awarded from a Hess cycle)
$\Delta H = (4 \times 44) + (4 \times -286) + (4 \times -393) - -245$
$\Delta H = -2295\ (\text{kJ mol}^{-1})$ ✓

e) Incomplete combustion ✓ (IF candidate answers 'not stirred', accept only if d) was incorrect and value obtained in d) was too exothermic a value)

f) ΔH is negative and ΔS is positive ✓
There is an activation energy barrier to combustion ✓

17 a) $p = \frac{nRT}{V}$ ✓
$p = \frac{0.0005 \times 8.31 \times 283}{2.5 \times 10^{-3}}$ ✓
$p = 470\ (\text{Pa})$ ✓

b) $K_p = \frac{p(H_2O)^2 \times p(Cl_2)^2}{p(HCl)^4 \times p(O_2)}$ ✓

	HCl	O_2	H_2O	Cl_2
Moles (initial)	0.056	0.0765	0.00	0.00
Moles (eqm)	0.02	0.0675	0.018	0.018

✓ (Correct eqm moles)
Total moles = 0.1235

	HCl	O_2	H_2O	Cl_2
Partial pressure	$\frac{0.02 \times 0.025}{0.1235}$	$\frac{0.0675 \times 0.025}{0.1235}$	$\frac{0.018 \times 0.025}{0.1235}$	$\frac{0.018 \times 0.025}{0.1235}$
Partial pressure	0.00405	0.01366	0.00364	0.00364

✓ (ALLOW ECF from incorrect moles)
$K_p = \frac{0.00364^2 \times 0.00364^2}{0.00405^4 \times 0.01366}$
$K_p = 48.0$ ✓
ALLOW ECF from incorrect partial pressures

c) $K_p = \frac{kPa^2 \times kPa^2}{kPa^4 \times kPa} = kPa^{-1}$ ✓

d) i) $6\,NaOH + 3\,Cl_2 \rightarrow NaClO_3 + 5\,NaCl + 3\,H_2O$ ✓ species ✓ balanced

ii) Disproportionation is when an element is oxidised and reduced in the same reaction ✓
Chlorine goes from (0) to (+V) and (-I) ✓

iii) Making bleach

e) i) Chlorine has fewer shells of electrons / is smaller than iodine ORA ✓
Outer electrons have less shielding in chlorine than iodine ORA ✓
Therefore, chlorine has a greater nuclear attraction for an additional electron than iodine ORA ✓

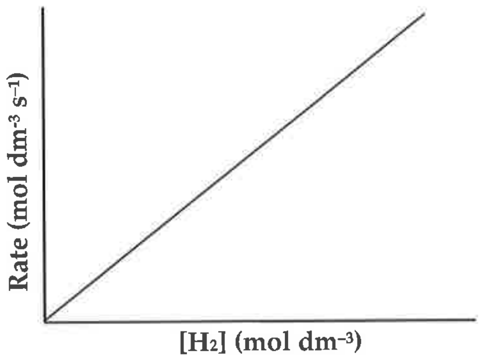
ii)

<table>
<tr><th colspan="2">LEVEL OF RESPONSE QUESTION</th></tr>
<tr><td>Level 3: (5–6 marks)</td><td>The practical procedure is described in a comprehensive and logical fashion.
The observations are described and explained.
A correct equation is given.</td></tr>
<tr><td>Level 2: (3–4 marks)</td><td>The practical procedure is described, but omits some details or is not described in a completely logical order.
Most observations are described AND explanations are mostly correct.
A correct equation may be given.</td></tr>
<tr><td>Level 1: (1–2 marks)</td><td>Some suggestions for an experimental procedure are given, but not in a logical order.
Most observations are described OR a correct explanation is given.</td></tr>
<tr><td>0 marks</td><td>No creditworthy response.</td></tr>
<tr><td colspan="2">• Dissolve the potassium bromide in water and add some to a test tube
• Add a small quantity of chlorine water to one, and iodine solution to the other
• Shake
• Colour change of solution from pale green to orange with bromine
• Iodine solution remains brown
• Bromide ions and chlorine have reacted to form chloride ions and bromine
• Iodine cannot oxidise bromide ions
• Chlorine is more reactive than bromine, but iodine is less reactive than bromine
• Organic solvent (e.g. cyclohexane) can be used to confirm result. Organic layer remains purple with the iodine solution, but changes from pale green to orange with the chlorine water.
• $Cl_2 + 2\,Br^- \rightarrow Br_2 + 2\,Cl^-$</td></tr>
</table>

18 a) i) Simple (molecular) lattice ✓
Held together by intermolecular forces between molecules (ALLOW references to specific intermolecular force, i.e. van der Waals forces) ✓
Iodine monochloride has stronger intermolecular forces / van der Waals forces ORA✓
So more energy is needed to separate the molecules, meaning that melting and boiling points are higher ORA ✓

ii) Hydrogen chloride is polar / contains a dipole, whereas Cl_2 is not ✓
Hydrogen chloride can form (electrostatic) attractions with water molecules because water is also polar ✓

b) i)



Straight line with positive gradient ✓

ii) Scale that covers half the graph paper AND axes labelled. IGNORE units ✓
Plot of ln k against 1/T ✓
Correct calculation of values ✓

1/T (K^{-1})	ln k
0.00500	11.3
0.00333	15.9
0.00250	18.2
0.00200	19.6
0.00167	20.5

All five points in correct place (this mark can be awarded from incorrect values) ✓
Measurement of gradient to be -2.8×10^3 (Accept between -2.5×10^3 and -3.0×10^3) ✓
Gradient = $-\frac{E_a}{R}$ so $E_a = -8.314 \times$ gradient = 2.30×10^4 J mol^{-1} = 23 kJ mol^{-1} (Accept correct manipulation from gradient ✓
Intercept = ln A so A = $e^{\text{Intercept}}$ Accept values in range 4.0×10^{10} to 2.0×10^{11} ✓

c) i) The catalyst is in the same state as the reactants

ii) It would be less steep (because E_a would be less) ALLOW AW

19 a) i) The mass of an atom of an isotope relative to the mass of $\frac{1}{12}$th ✓
of the mass of a ^{12}C atom ✓

ii)

Molecule	Number of neutrons
$^{16}O{-}^{16}O$	16
$^{18}O{-}^{16}O$	18
$^{18}O{-}^{18}O$	20

Difference of 2 between each number ✓
Correct numbers ✓

b) $CO_2 + 6H^+ + 6e^- \rightleftharpoons CH_3OH + H_2O$ (ignore state symbols) ✓
$O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O$ (ignore state symbols) ✓
Multiplication of ① by 2 and ② by 3 ✓
$2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ (ignore state symbols) ✓

c) i) Non-toxic components
Lithium cells have risk of fire
Doesn't need to be recharged / continuous supply of fuel
(any of the above) ✓

ii) Methanol is a liquid while hydrogen is a gas AND easier/safer to store/transport ✓

d) ② – ① = 1.21 V
0.40 – ① = 1.21 V
② = -0.81 V ✓

20 a) A d–block element that forms an ion with an incomplete d subshell ✓

b) Chromium forms six coordinate bonds to six water ligands ✓
Each water donates a pair of electrons to chromium ✓

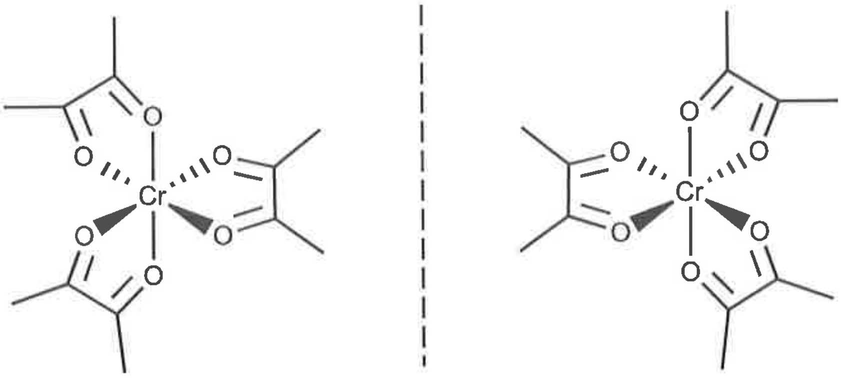
c) i) $[Cr(NH_3)]^{3+}$ ✓

ii) Green ✓ to purple ✓

iii) Ligand substitution ✓

d) $[Cr(H_2O)_6]^{3+} + 3\ CH_3COCOCH_3 \rightleftharpoons [Cr(CH_3COCOCH_3)_3]^{3+} + 6H_2O$
Correct formula of product complex ✓
Balanced equation ✓

e)



Chromium bonded to three bidentate ligands ✓
Correct octahedral structure of one complex ✓
Correct optical isomer drawn ✓
Explanation: these complexes are non-superimposable mirror images ✓

21 a) (One molecule of phosphoric acid) can donate three protons ✓

b) $K_a\ (KH_2PO_4) = 10^{-pKa} = 10^{-7.21} = 6.17 \times 10^{-8}$ ✓

$[H^+]$ in desired solution = $10^{-pH} = 10^{-7.40} = 3.98 \times 10^{-8}$ ✓

$[KHPO_4-] = \frac{[KH_2PO_4] \times K_a}{[H^+]}$ ✓

$[KHPO_4-] = \frac{0.100 \times 6.17 \times 10^{-8}}{3.98 \times 10^{-8}} = 0.155\ (\text{mol dm}^{-3})$ ✓ ALLOW ECF from incorrect K_a or $[H^+]$

c)

LEVEL OF RESPONSE QUESTION	
Level 3: (5–6 marks)	Answer is very well organised. Description of the purpose of the buffer, and explanations of how it works on both increase AND decrease in pH are correct.
Level 2: (3–4 marks)	Answer is reasonably well structured. Some indication of the purpose of the buffer is given, and explanation of how it works upon either an increase OR decrease in pH is given.
Level 1: (1–2 marks)	Answer has little structuring of points. A vague description of the purpose of the buffer is given, relating to control of pH. Shifting in the position of equilibrium is mentioned, without inclusion of the direction or species involved.
0 marks	No creditworthy response.

Indicative Content

Role

- The buffer **minimises** any change in pH
- On addition of a small amount of acid or base

Explanation (accept AQ throughout)

- $H_2CO_3 \rightleftharpoons HCO_3^- + H^+$
- High concentration of H_2CO_3/HCO_3^- compared to the concentration of H^+

- If there is an increased number of H^+ ions, they react with the HCO_3^- ions
- Equilibrium shifts left

- If there is an increase in pH, $[H^+]$ drops (ALLOW $H^+ + OH^- \rightarrow H_2O$)
- Hydrogen carbonate equilibrium shifts right to replace H^+ ions