UNIT TEST C4

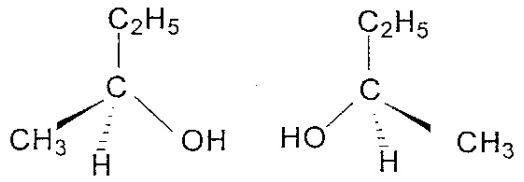
6244

MARK SCHEME

JUNE 2002

1 (a) (i) Has two isomers that are non-superimposable **(1)**
mirror images **(1)** *not stand alone*
or
The **molecule** does not have a plane of symmetry **(2)**
or
The molecule contains a single **(1)** asymmetric carbon atom **(1)** **2**

(ii)



One correct 3 –D diagram **(1)**
second molecule mirror image of first as drawn **(1)**
Stand alone provided two tetrahedral mirror image drawn of C_4H_9OH **2**

(iii) **Rotates** the plane of plane polarised (monochromatic) light **(1)**
in opposite directions **(1)**
Consequential on mention of polarised light.
or
Use polarimeter **(1)**
measure rotation (of plane of polarised light) in opposite directions **(1)** **2**

(b) (i) $CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$ **(1)**
Any valid ester equation scores the mark but must be actual molecules not ROH or RCOOH
Equilibrium sign not important **1**

(ii) double alcohol / alcohol at each end **(1)**
double acid / acid at each end **(1)**
or
Alcohol group at one end and acid group at the other **(2)**
Could be shown on an equation or as diagrams
React at each end / illustrate with equation or diagram to show production of a long chain polyester **(1)** **3**

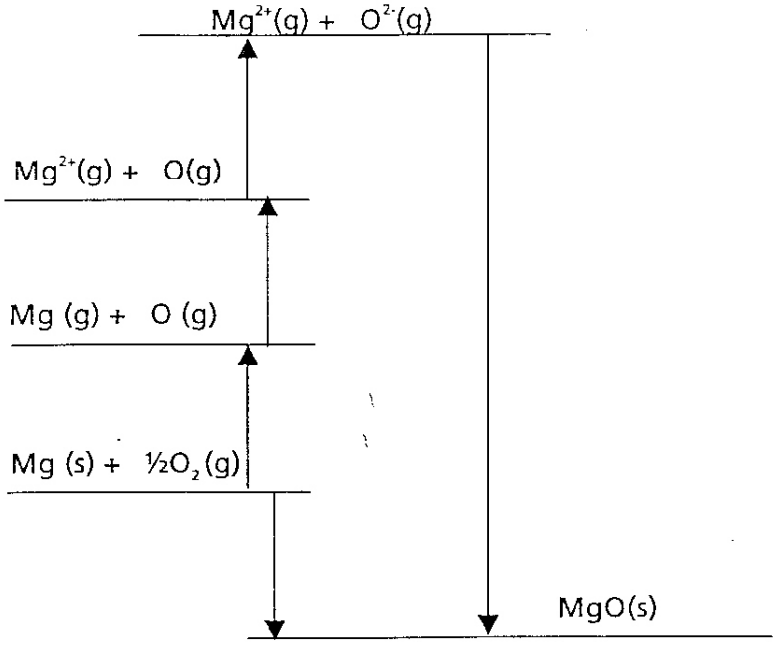
(iii) Esters react with alkalis / ester linkages are hydrolysed **(1)**
conc / hot will attack polyesters / coat will be damaged / too slowly to be a problem **(1)**
Second mark consequential on first **2**

(iv) Acyl chlorides / acid chlorides / acid halides / RCOCl / acid anhydride **(1)** **1**
Not specific reagent

Total marks for question 13

2 (a) $O^-(g) + e \rightarrow O^{2-}(g)$
3 species **(1)**
state symbols **(1)** *not stand alone* **2**

(b)



(2)

Marking points on cycle
Show all state symbols **(1)**
Shows cycle where arrows link correct species **(1)**
Calc:
150 + ½(496) + 736 + 1450 + 602 + x = 142 + 3889 **(1)**
x = +845 (k J mol^{-1}) **(1)**
½ x (496) is key point

4

(c) (i) Lattice enthalpy depends on charges and the ionic radii / charge densities **(1)**
Comparison of Na^+/ Mg^{2+} size **and** charge **(1)**
Comparison of Cl^- / O^{2-} size **and** charge **(1)**
(High LE results from) higher interaction **(1)** **4**
Must be ions not atoms
Could define what charge density is and use this to answer question for 4 marks
May use formulae of ions or name of ion

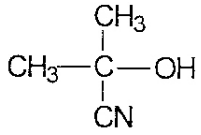
(ii) Hydration enthalpy / solvation enthalpy **(1)** **1**

(iii) Solubility depends on the balance between ΔH lattice enthalpy and ΔH hydration **(1)** *need idea of "balance"*
LE too big to be overcome by HE **(1)** **2**
Could be shown as an equation such as

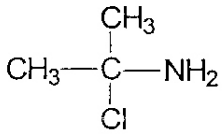
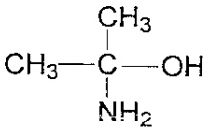
$\Delta H_{sol} = \Delta H_{hyd} - \Delta H_{lattice}$

Total marks for question 13

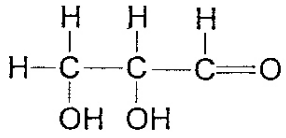
3 (a) **H** is CHI_3 **(1)**
J is CH_3COONa/CH_3COO^- **(1)**
Not CH_3COOH
Note *H and J can be reversed*

K is  **(1)** *If cyanide group shown displayed show C≡N must be correct*

Allow $CH_3C(OH)(CN)CH_3$ only if brackets present

M is  or  **(1)**

(b) *Reagent 1* Named dilute acid / correct formula e.g.HCl(aq) or NaOH (aq) then add HCl **(1)**
Allow conc HCl
Reagent 2 PCl_5 / $SOCl_2$ / PCl_3 / or name **(1)**
Reagent 3 (Conc) ammonia (solution) / NH_3 **(1)** **3**

(c) (i)  *Insist on C to O bond*
(1) **1**

(ii) 2,3-dihydroxypropanal **(1)** and 2-oxopropanoic acid **(1)**
yellow / orange / orange-red ppt / solid / crystals **(1)** **3**

(iii)
- Add Fehlings' solution / Benedicts' solution **(1)** red/orange ppt for2,3-dihydroxypropanal **and** no result for 2-oxopropanoic acid **(1)**
- Add ammoniacal silver nitrate**(1)** silver mirror for2,3-dihydroxypropanal **and** no result for 2-oxopropanoic acid **(1)**
- Add named carbonate **(1)** effervescence / bubbling for 2-oxopropanoic acid and no result for2,3-dihydroxypropanal **(1)**
- Add iodine + sodium hydroxide solution / KI + NaClO **(1)** yellow ppt for 2-oxopropanoic acid **and** no result for2,3-dihydroxypropanal **(1)**
- Add dilute sulphuric acid + potassium dichromate **(1)** dichromate goes green for 2,3-dihydroxypropanal **and** no result for 2-oxopropanoic acid **(1)**
- Dissolve in water add stated indicator **(1)** two appropriate colour changes**(1)** **2**

Total marks for question 13

4 (a) (i) $MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$
balanced correct equation **(1)**
state symbols **(1)***not stand alone* **2**

(ii) White solid **(1)**
dissolves to colourless solution**(1)** **2**

(b) (i) $P_4O_{10} + 12NaOH \rightarrow 4Na_3PO_4 + 6H_2O$
$P_4O_{10} + 8NaOH \rightarrow 4Na_2HPO_4 + 2H_2O$
$P_4O_{10} + 4NaOH + 2H_2O \rightarrow 4NaH_2PO_4$
species **(1)** balance **(1)** **2**
If use P_2O_5 in place of P_4O_{10} equation above divided by 2
Do not accept polyphosphates

(ii) $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$**(1)**
$Al(OH)_3 + 3H^+ \rightarrow Al^{3+} + 3H_2O$
$Al(OH)_3 + 3NaOH \rightarrow Na_3Al(OH)_6$
$Al(OH)_3 + NaOH \rightarrow NaAl(OH)_4$**(1)**
Also
$Al(OH)_3 + 3OH^- \rightarrow Al(OH)_6^{3-}$
$Al(OH)_3 + OH^- \rightarrow AlO_2^- + 2H_2O$
$Al(OH)_3 + OH^- + \rightarrow Al(OH)_4$
Two equations starting with $Al(OH)_3$ showing understanding of the term amphoteric **(1)**
ie 2 equations, one reaction with ACID and one with ALKALI **3**

(c) Describe trend eg from metallic to non-metallic as move from left to right across Period 3 **(1)**
Justification of trend by reference to acid / base props of Mg, Al and P **(1)** **2**

(d) Oxides more basic as a group is descended **(1)**
Indium oxide would probably be (more) basic (than aluminium) **(1)** **2**

Total marks for question 13

5 (a) (i) fraction of the total pressure generated by a gas or
or
pressure gas would generate if it alone occupied the volume
or
P_{total} x mol fraction **(1)** **1**

(ii) $K_p = \frac{p(CO) \times p(H_2)^3}{p(CH_4) \times p(H_2O)}$ **(1)** not [ ] **1**

(iii) Increase in total pressure will result in less product molecules in the equilibrium mixture / equilibrium moves to left **(1)**
because more molecules on product side of the equilibrium than on left **(1)** **1**

(b) (i) No change **(1)** **1**
(ii) K_p increase **(1)** **1**
(iii) No change **(1)** **1**

(c) (i) $K_p = \frac{1}{p(CH_4)}$ **(1)** **1**

(ii) 9.87×10^{-3} kPa^{-1} / 9.87×10^{-6} Pa^{-1} consequential on (i) **(1)** **1**
Allow 3 – 5 sig fig

(iii) equilibrium has moved left in favour of gas **(1)**
exothermic going left to right/in the forward direction / as written **(1)** *Stand alone* **1**

(iv) Answer yes or no with some sensible justification **(1)**
e.g. No the costs would not justify the amount produced **1**

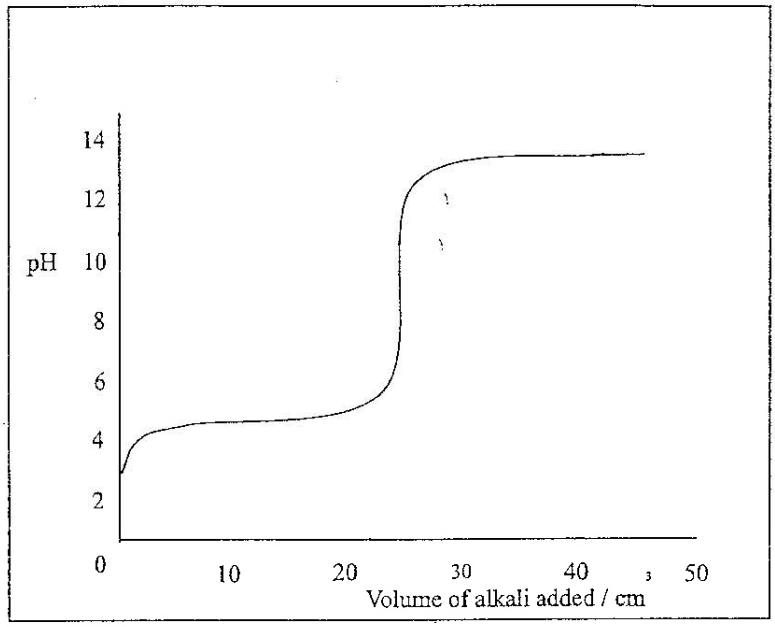
Total marks for question 12

6 (a) Few molecules dissociate (into protons) / partially dissociated / ionised **(1)** **1**

Not fully dissociated scores zero

(b) Maintains an **almost** constant pH / resists change in pH **(1)**
with the addition of **small** amounts of acid or alkali **(1)** **2**

(c)



starting pH**(1)** at 2.8
endpoint **(1)** vertical between 6 and 11 including 7-10
vertical**(1)** at 25 cm^3
general shape **(1)** finish above 12 **4**

(d) Almost horizontal area marked on graph **(1)** **1**

(e) (i) $K_a = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ **(1)**

or

$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$ **(1)** **1**

(ii) pH= pK_a at half way to neutralisation point = 12.5 cm^3 (1)
This could be shown on the graph
because pH = pK_a when $[CH_3COO^-] = [CH_3COOH]$**(1)** **2**

Total marks for question **11**

Paper total 75 marks

UNIT TEST C5

6245

MARK SCHEME

JUNE 2002

1 (a) (i) Working to show first order with respect to $[S_2O_8^{2-}]$ **(1)**
Working to show first order with respect to $[I^-]$ **(1)**
overall equation**(1)** **3**
Consequential

(ii) Sum of power of the concentration terms (for thio and iodide) in rate equation / number of each species involved up to and including or, in, the rate-determining step in the reaction mechanism / Sum of the partial / individual orders / general equation of the form $[thio]^m[iodide]^n$ overall order = m + n **(1)** **1**

(iii) 36 **(1)** $dm^3mol^{-1}s^{-1}$ **(1)** **2**
Consequential on part (i)

(iv) Rate equation depends on mechanism / rate equation only involves those species in the rate determining step / slowest step**(1)** **1**

(b) (i) Colorimetry / conductivity / remove samples and titrate with (standard) sodium thiosulphate solution **(1)** **1**

(ii) Constant temperature **(1)** **1**

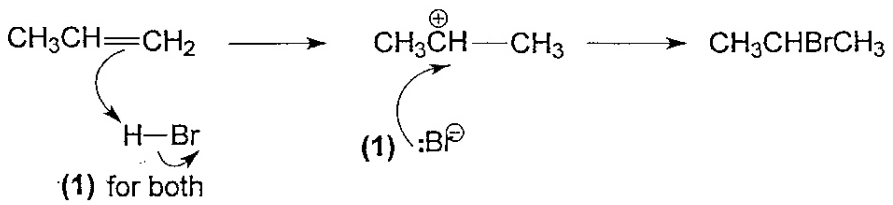
(iii) Colorimeter / conductivity **adv** that monitoring is continuous / does not need removal of samples
or
disadv of titration is problems with timing **(1)** **1**

Total marks for question **10**

2 (a) Species seeking negative charge / electron deficient / electron **pair** (lone pair) acceptor **(1)** **1**
*If say **must** be a positive ion then zero marks*

(b) (i) 2-bromopropane **(1)** **1**

(ii) **(1)** for structure



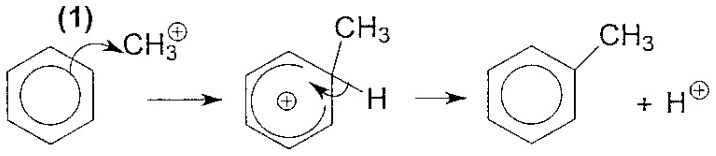
*The arrow for the attack of the bromide ion must **not** go from the negative charge.* **3**
*Do **not** need lone pair of electrons on the bromide*
If mechanism gives 1-bromopropane can get first and third mark

(iii) (major product) involves 2° carbocation as intermediate **(1)** which is more stable than / has a lower E_a of formation than the 1° carbocation / more electron releasing groups around the carbon atom**(1)** **2**

This could be shown as diagrams

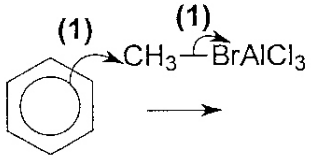
(c) (i) Aluminium chloride / iron(III) chloride / iron / or bromides / correct formulae **(1)** **1**

(ii) $CH_3Br + AlCl_3 \rightarrow CH_3^{\oplus} + BrAlCl_3^{\ominus}$ **(1)**



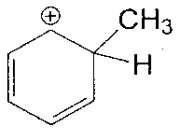
(1) for arrow
(1) for structure

alternative way
of showing part played by catalyst



4

Kekulé intermediate



(d)
- delocalised π electron / from p-orbitals system in benzene **(1)**
- substitution enables delocalisation to be preserved **(1)**
- π bond in propene weaker than π bond in benzene **(1)**
- (π bond broken in) formation of two single bonds (on addition to propene) which is energetically more favourable than substitution **(1)**

4

Total marks for question 16

3 (a)

Sc	[Ar]	↑					↑↓
Cr	[Ar]	↑	↑	↑	↑	↑	↑
Cr^{3+}	[Ar]	↑	↑	↑			

3

Cr^{3+} consequential on structure for Cr

(b) Electronic configuration differs from previous element by an electron in a d (sub) shell / electrons are filling the d-shell **(1)**
transition elements have one ion with partially-filled d-shell **(1)** **2**

Not *'highest energy shell is the 'd'-shell*
outer electron in 'd' shell

(c) (i)

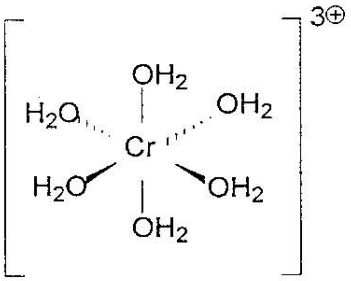
[Ar]	↑	↑	↑	↑↓	↑↓		↑↓		↑↓	↑↓	↑↓

Ligand electrons

2

Correct electron structure for complex ion **(1)**
ligand electrons identified **(1)** 6 pairs identified stand alone mark
Consequential on structure of Cr^{3+}

(ii)



1

(1)

There must be some attempt to show a 3-D structure
'Octahedral' could rescue a poor diagram

(iii) d-orbitals split (in energy by ligands) / or diagram to illustrate **(1)**
electron transitions / jumps from **lower** to **higher** energy level **(1)**
absorbs light in visible region **(1)** **3**

(d) (i) Green **precipitate (1)**
(deep) green **solution** in excess sodium hydroxide **(1)** **2**

(ii) Deprotonation / acid base **(1)** **1**

Total marks for question 14

4 (a)

VO_2^+	yellow	VO^{2+}	blue
V^{3+}	green	V^{2+}	Lavender/mauve/lilac/purple/violet

2

All four correct **2 marks** - any 2 correct **1 mark**

(b) (i) $2VO_2^+ + Zn + 4H^+ \rightarrow 2VO^{2+} + 2H_2O + Zn^{2+}$
species **(1)** balance **(1)** **2**

(ii) V^{3+}
or
V^{3+} and VO^{2+}**(1)** allow $[V(H_2O)_6]^{3+}$
E value for both reduction reactions positive so feasible **(1)**
(further) reduction (to V^{2+}) not feasible / E value negative**(1)** **3**

(c) (i) Disproportionation requires the original oxidation states to be able to both rise and fall **(1)**
or
In disproportionation a species must be able to be reduced and to be oxidised thus needs 3 oxidation states **(1)** **1**

(ii) $2VO^{2+} \rightarrow VO_2^+ + V^{3+}$
species **(1)** balance **(1)** **2**

Total marks for question 10

5 (a) $2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$ / or clearly stated **(1)**

amount of thio = 26.8 x 0.1 / 1000 = 2.68×10^{-3} mol**(1)**

ratio of copper to thio is 1:1 **(1)**

total amount of copper = 2.68×10^{-3} mol x 10 = 2.68×10^{-2} mol **(1)**

mass of copper = 2.68×10^{-2} mol x 63.5 g mol^{-1} = 1.70g **(1)**

purity = 1.70x100 / 1.74 = 97.8 / 97.7 % **(1)** **6**

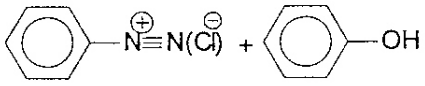
allow 2 to 4 sig figs in final answer mark consequentially

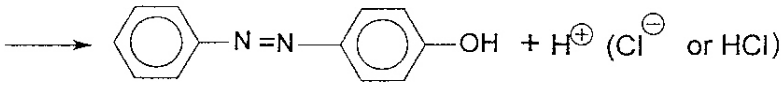
(b) The increase in successive ionisation energies is similar **(1)**
compensated for by bond formation or hydration enthalpy or energy or lattice enthalpy **(1)**
catalysis involves metal ion moving from one oxidation state to another **(1)**
and back **(1)** **4**

(c) (i) Sodium nitrite + aq / conc / dilute HCl / hydrochloric acid **(1)**
any temperature between 0 and 10 °C or a range between 0 & 10°C **(1)** **2**

(ii) If too cold reaction too slow**(1)**
if too warm product or nitrous acid decomposes / products would be phenol and nitrogen **(1)** **2**

(iii)



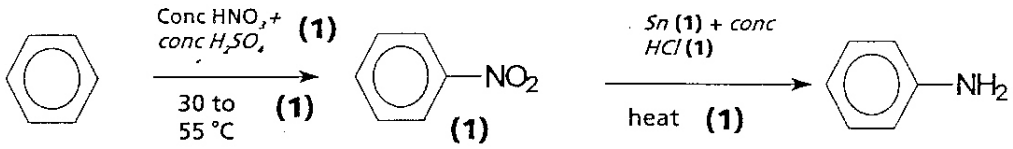


3 structures **(2)**
2 structures **(1)**
Balance **(1)**

It is not necessary to show the full structure for the diazo compound e.g $C_6H_5N_2^+$ is acceptable.

Conditions - phenol in alkali **(1)** yellow / orange / red ppt **(1)** **5**

(d)



6

Condition mark depends on reasonable reagents
If give alternative route then –1 for each error
Name of nitrobenzene acceptable

Total marks for question 25

6 (a) (i) Magnesium**(1)**
Dry Ether**(1)** **2**

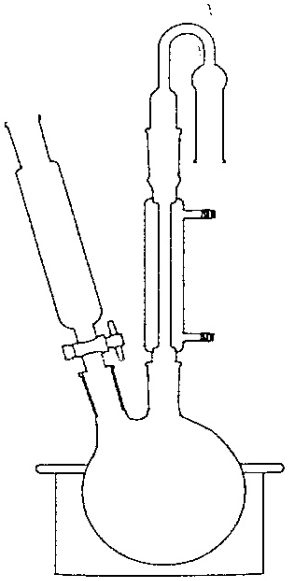
(ii) (Solid) carbon dioxide **(1)** then / followed by dilute HCl**(1)** **2**
Carbon dioxide *and dil HCl scores 1 mark*
Any named mineral acid can score
Ignore state of carbon dioxide

(b) (i) (ether) flammable **(1)**
No naked flames / use water bath / heating mantle**(1)** **2**

(ii)

This is a diagrammatic representation of a set up that could be used. The marks are for the particular elements not their orientation

Some means of adding bromoethane safely.
Or
Calcium chloride drying tube



Reflux condenser

Magnesium
+
ether
+
(iodine)

Water bath / heating mantle
This mark lost if Bunsen present or heat ↑

Marking
Flask + Reflux condenser **(1)**
Water bath / heating mantle **(1)** Consequential on first mark
Some means of excluding water vapour e.g. calcium chloride guard tube **or** some means of adding reactants without danger **(1)** **4**

Overall diagram **(1)** this must work and this must be safe i.e. not closed
show as **✓Q**

UNIT TEST C6B

6246 B

MARK SCHEME

JUNE 2002

1 (a)

Sig fig 2 to 4 penalise only once in paper

The marks are for each process

amount NaOH = 0.028 dm^3 x 0.100 mol dm^{-3} = 2.8 x 10^{-3} mol **(1)**

amount $(NH_4)_2SO_4$ in 25 cm^3 = 1.4 x 10^{-3} mol **(1)**

look for divide by 2 to give correct calculation

total amount $(NH_4)_2SO_4$ = 0.014 mol **(1)**

look for x 10 to give correct calculation

mass $(NH_4)_2SO_4$ = 0.014 mol x 132 g mol^{-1} = 1.85 g **(1)**

look for x 132

% ammonium salt in fertiliser $\frac{1.85 \times 100}{3.80}$ = 48.6% **(1)** **5**

% mass of ammonium sulphate calculated.

Notes:

- *If get maths wrong lose process mark*
- *Simple answer plus no working 1 mark*

(b) Loss of ammonia **(1)** *stand alone mark*
Incomplete distillation / not all of the ammonia driven off **(1)**
Incomplete absorption **(1) MAX 2** **2**

(c) (i) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
symbols **(1)**
states **(1)** *not stand alone*
ignore correct spectator ions shown on both sides **2**

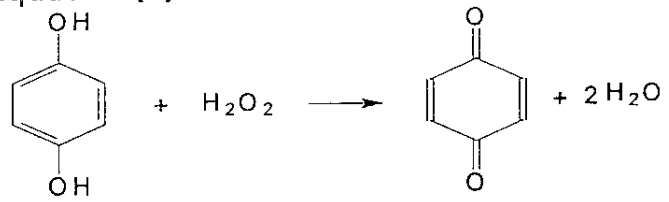
(ii) Ensures complete precipitation / reaction of **all** the sulphate (ions) **(1)** **1**
not ammonium sulphate

(d) (thermal) decomposition (of the carbonate) **(1)**
giving a lower mass / carbon dioxide escapes (from system) with clear implication that this is responsible for a lower mass **(1)**
for choosing a correct carbonate **(1)** *this may be shown in the equation (not group 1 except Li, not Be/Ba/Al)*
$CaCO_3 \rightarrow CaO + CO_2$ **(1)** *this mark is not consequential on third mark*

4

Total marks for question 14

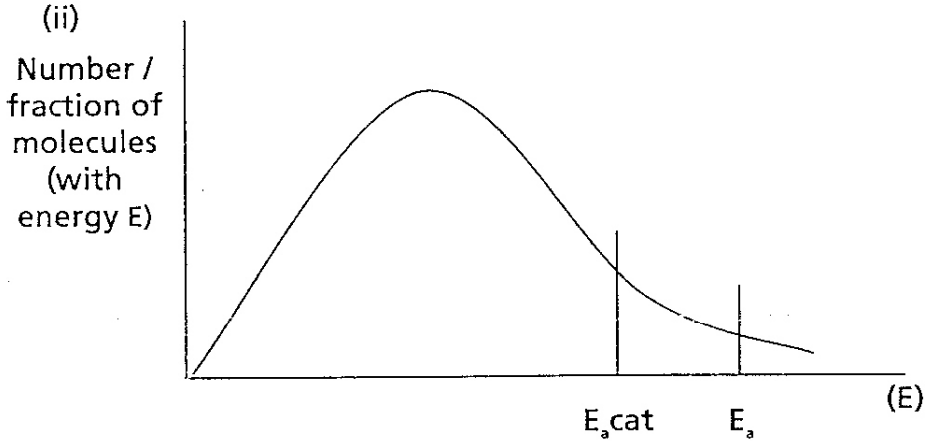
2 (a) (i) Equation **(1)**



There are several ways of answering the rest of this section
Alternative 1
E = + 2.47V **(1)**
This is positive, therefore reaction feasible**(1)**
Alternative 2
Both $E^{\ominus}$ values are positive, so sum of $E^{\ominus}$ is positive **(1)**
Therefore reaction is feasible **(1)**

3

(ii)



Maxwell-Boltzmann graph - **1 mark** for shape of graph
1 mark for correct axes plotted and labelled
1 mark for E_a and $E_a$cat
Do not award third mark if either of the E values is on left hand side of max on hump
Explanation
area under graph to right of E_{cat} > area to right of E_a **(1)**
greater number / fraction of molecules or particles have enough energy to react on collision or greater number of effective / successful collisions **(1)**
If draw two graphs showing different temperature - ignore

5

(iii) The reactant / 1,4-dihydroxybenzene (and the product / quinone both) have delocalised ring (or resonance) systems/ or described delocalisation (or resonance) **(1)**
these average bond energies are for localised bonds / do not apply to benzene ring compounds / compounds with delocalised or resonance systems.**(1)** **2**

(b) 20 dm^3 oxygen is 20/24 = 0.833 mol **(1)**
amount peroxide in 1 dm^3 = 0.833 mol x 2 **(1)** = 1.67 mol
mass = 1.67 mol x 34 g mol^{-1} = 57 / 56.6 / 56.7 / 56.8 g (dm^{-3}) **(1)** **3**

(c) (i) $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$ **(1)** **1**

(ii) $2MnO_4^- + 6H^+ + 5H_2O_2 \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$
species on correct side of equation **(1)** balance **(1)** **2**

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ *If the overall equation is not correct allow 1 mark for this equation if correct*
ignore $\rightleftharpoons$

(iii) Higher concentration increases collision frequency / more collisions per unit of time **(1)**
therefore causes increase in reaction rate **(1)**
More successful collisions therefore faster gets 1 mark(no reference to higher concentration) **2**

Total marks for question 18

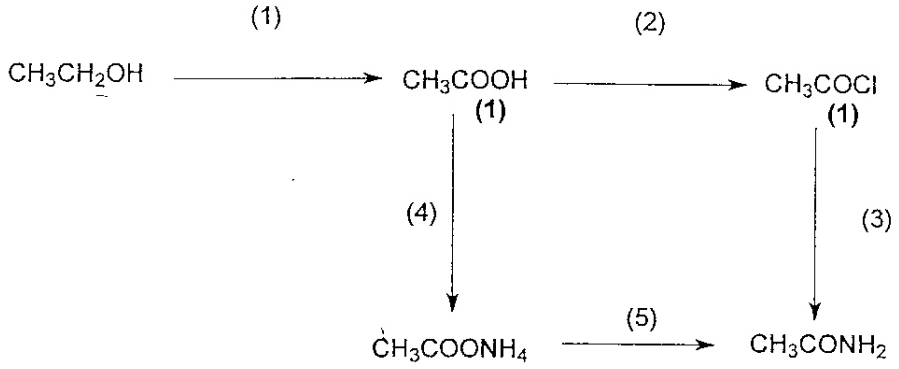
3 (a) Spectra shows three types / environment of hydrogen **(1)**
Each peak related to type of hydrogen in ethanol **(1)**
References to mass spec score zero **2**

(b) (i) Conc.sulphuric acid would produce (some) bromine **(1)**
50% acid produces HBr **only (1)** **2**

(ii) Ammonia **(1)** heat in sealed tube / under pressure**(1)**
or
Concentrated ammonia **(1)** at room temperature **(1)** **2**

(iii) Acid protonates $-NH_2$ (to $-NH_3^+$) / $-NH_2$ reacts with H^+ (not HCl) **(1)**
ionic more soluble **(1)** **2**

(c) *If 3 steps that works*
Correct intermediates score ***2 marks***
Any 3 correct reagents score ***3 x 1 marks***
Any one correct condition scores ***1 mark***

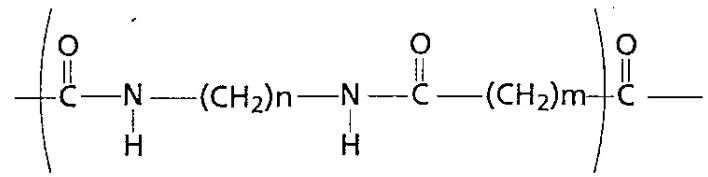


Step	Reagent	Conditions
1	Potassium dichromate + named mineral acid or potassium manganate(VII) with sulphuric acid	Heat under reflux
2	PCl_3 / PCl_5 / $SOCl_2$	Dry / room temperature
3	Ammonia	Room temperature
4	Ammonia	Room temperature
5	Heat	

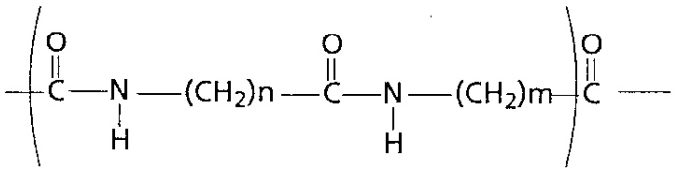
6

If scheme breaks down mark from start to breakdown and from end back to breakdown and score best of these two marks
names or correct formulae allowed.
Name scores even if formulae then given and wrong

(d) (i)



or



(1) **1**

(CH_2)n or m represents a sensible unit which may be a benzene ring

(ii) $H_2N\text{-}(CH_2)_n\text{-}NH_2$ and $ClOC\text{-}(CH_2)_m\text{-}COCl$
(1) **(1)** **2**

Consequential on (i)
Allow caprolactan (2 marks)
or cyclic compound
$H_2N\text{-}(CH_2)_n\text{-}COCl$ scores 2 marks

(iii) Toxic if burnt / non-biodegradable **(1)** **1**

Total marks question marks **18**

4 (a) The marks are for:

- writing the expression for K
- substituting correctly
- calculating $p(SO_3)$
- correct generation of the ratio
- calculation of the ratio to give answer which rounds to 95 t

$Kp = pSO_3^2 / pSO_2^2 \times pO_2$ (= 3.00×10^4)**(1)**

$3.00 \times 10^4 = pSO_3^2 / 0.1 \times 0.1 \times 0.5$ **(1)** *if no expression for Kp is given this correct substitution can score 2 marks*

$pSO_3^2 = 150$

$pSO_3 = 12.25$ **(1)**

Ratio of $SO_3 = \frac{12.25 \times 100\%}{(12.25 + 0.1 + 0.5)}$ **(1)** = 95% **(1)** **5**

(b) (i) The marks are for

- Recognizing the existence of hydrogen bonds (between molecules) **(1)**
- That each molecule can form more than one hydrogen bond because of the two OH (and two S=O groups) / or a description of hydrogen bonds in this case / or a diagram showing the hydrogen bonds **(1)**
- That hydrogen bonds make for strong intermolecular forces (and hence high boiling temperature) which requires higher **energy** to break / separate molecules **(1)** **3**

(ii) If water is added to acid heat generated boils and liquid spits out **(1)**
if acid added to water the large volume of water absorbs the heat generated (and the mixture does not boil) **(1)** **2**

(c) (i) $pH = -\log_{10}(0.200) = 0.70$ **(1)**
allow 0.7 or 0.699

(ii)
- realising that the **first** ionisation / dissociation of sulphuric and that of HCl are **both** complete **(1)**
- that the second ionisation of sulphuric is suppressed by the H^+ from the first **(1)**
- little contribution from 2nd ionisation so reduces the pH very little / increases the $[H^+]$ very little **(1)** **3**

(d) (i) Lead equations 1 mark

$Pb + H_2SO_4 \rightarrow PbSO_4 + 2H^+ + 2e^-$ **(1)**

or

$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$

Lead(IV) oxide equations 2 marks

$PbO_2 + H_2SO_4 + 2H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$

or

$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O +$

Species **(1)** balancing **(1)** **3**

(ii) $PbO_2 + Pb + 2H_2SO_4 \rightarrow 2PbSO_4 + 2H_2O$ **(1)** **1**

Total marks for question **18**