X012/701

NATIONAL QUALIFICATIONS 2011

THURSDAY, 26 MAY 9.00 AM – 11.30 AM

CHEMISTRY ADVANCED HIGHER

Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet .

SECTION A – 40 marks

Instructions for completion of **SECTION A** are given on page two.

For this section of the examination you must use an **HB pencil**.

SECTION B – 60 marks

All questions should be attempted.

Answers must be written clearly and legibly in ink.

SECTION A

Read carefully

1 Check that the answer sheet provided is for **Chemistry Advanced Higher (Section A)**.

2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.

3 Check that the answer sheet you have been given has **your name**, **date of birth**, **SCN** (Scottish Candidate Number) and **Centre Name** printed on it.

Do not change any of these details.

4 If any of this information is wrong, tell the Invigilator immediately.

5 If this information is correct, **print** your name and seat number in the boxes provided.

6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).

7 There is **only one correct** answer to each question.

8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.

9 At the end of the exam, put the **answer sheet for Section A inside the front cover of your answer book**.

Sample Question

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

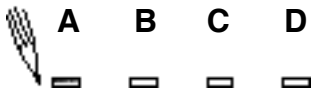
A chromatography

B fractional distillation

C fractional crystallisation

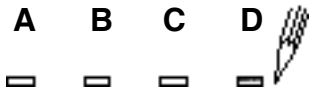
D filtration.

The correct answer is **A—**chromatography. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).

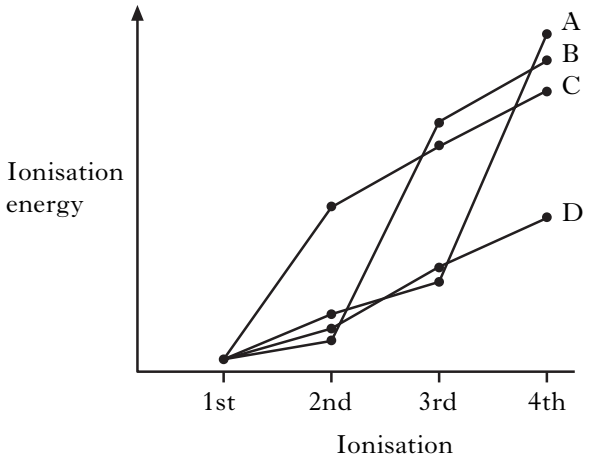


Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



1. Which of the following lines on the graph represents the trend in successive ionisation energies of a Group 3 element?



2. In colorimetry, as the concentration of a coloured solution decreases

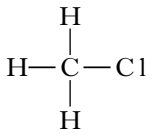
A the absorbance increases

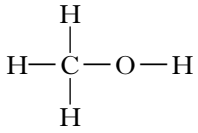
B the absorbance decreases

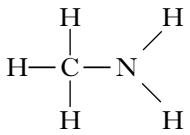
C the radiation wavelength increases

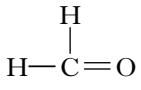
D the radiation wavelength decreases.

3. Which of the following molecules has the greatest number of non-bonding electron pairs (lone pairs)?

A 

B 

C 

D 

4. What is the change in the three-dimensional arrangement of the bonds round the P atom in the following reaction?

$PF_5 \rightarrow PF_3 + F_2$

A Tetrahedral to pyramidal

B Octahedral to trigonal planar

C Trigonal bipyramidal to pyramidal

D Trigonal bipyramidal to trigonal planar

5. The ratio of the ionic radii in sodium chloride is approximately 1:2, whereas in caesium chloride it is approximately 1:1. A compound XY contains X^+ ions with a radius of 133 pm and Y^- ions with a radius of 220 pm.

In a crystal of XY, how many Y^- ions surround each X^+ ion as its nearest neighbour?

A 1

B 2

C 6

D 8

6. An example of a p-type semiconductor is silicon doped with

A carbon

B arsenic

C aluminium

D phosphorus.

7. Which of the following solid oxides would **not** lower the pH when added to sodium hydroxide solution?

A Li_2O

B SiO_2

C P_4O_{10}

D Al_2O_3

[Turn over

8. Which of the following is least likely to produce fumes of hydrogen chloride when added to water?

A PCl_5

B $SiCl_4$

C $AlCl_3$

D $MgCl_2$

9. A white solid gives an orange-yellow flame colour. When added to water, hydrogen gas is released and an alkaline solution is formed.

The solid could be

A sodium oxide

B calcium oxide

C sodium hydride

D calcium hydride.

10. Which of the following ions is **least** likely to be coloured?

A $Ti(H_2O)_6^{3+}$

B $Cr(NH_3)_6^{3+}$

C $Ni(H_2O)_6^{2+}$

D $Zn(NH_3)_4^{2+}$

11. What volume of $0{\cdot}25\,mol\,l^{-1}$ calcium nitrate is required to make, by dilution with water, $500\,cm^3$ of a solution with a **nitrate** ion concentration of $0{\cdot}1\,mol\,l^{-1}$?

A $50\,cm^3$

B $100\,cm^3$

C $200\,cm^3$

D $400\,cm^3$

12. Hydrogen for use in ammonia production is produced by the endothermic reaction:

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

Which of the following will increase the equilibrium yield of hydrogen?

A Decrease the methane concentration

B Decrease the temperature

C Decrease the pressure

D Add a catalyst

13. The reaction

$CO(g) + 3H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

has an equilibrium constant of 3·9 at 950 °C.

The equilibrium concentrations of CO(g), $H_2(g)$ and $H_2O(g)$ are given in the table.

Substance	**Equilibrium concentration/mol l^{-1}**
CO(g)	0·500
$H_2(g)$	0·100
$H_2O(g)$	0·040

What is the equilibrium concentration of $CH_4(g)$, in $mol\,l^{-1}$, at 950 °C?

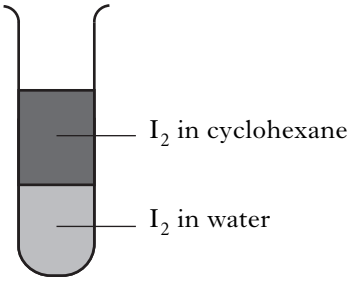
A 0·049

B 0·200

C 4·90

D 20·0

14.



The partition coefficient for the above system can be altered by

A adding more iodine

B adding more cyclohexane

C changing the temperature

D shaking the mixture thoroughly.

15. Gas liquid chromatography could be used to separate a mixture of hydrocarbons. The mixture is passed through a column packed with silica particles coated in a non-polar liquid. Helium can be used to carry the mixture through the column.

Which line in the table identifies correctly the stationary and mobile phases in this chromatographic separation?

	Stationary phase	**Mobile phase**
A	silica	helium
B	silica	non-polar liquid
C	non-polar liquid	helium
D	non-polar liquid	hydrocarbon mixture

16. Under certain conditions liquid ammonia ionises as shown:

$$2NH_3 \rightleftharpoons NH_4^+ + NH_2^-$$

Which line in the table shows the correct conjugate acid and conjugate base for this ionisation?

	Conjugate acid	**Conjugate base**
A	NH_3	NH_4^+
B	NH_4^+	NH_3
C	NH_2^-	NH_4^+
D	NH_4^+	NH_2^-

17. The activation energies for the reactions

(1) $H_2(g) + I_2(g) \rightarrow 2HI(g)$

(2) $2HI(g) \rightarrow H_2(g) + I_2(g)$

are 165 kJ and 179 kJ respectively. The enthalpy change for reaction (2) is

A −14 kJ

B +14 kJ

C −344 kJ

D +344 kJ.

18. The standard enthalpy of formation of strontium chloride is the enthalpy change for which of the following reactions?

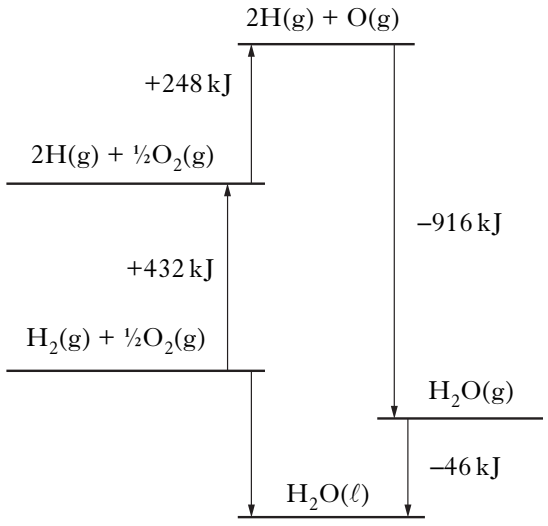
A $Sr(g) + Cl_2(g) \rightarrow SrCl_2(s)$

B $Sr(s) + Cl_2(g) \rightarrow SrCl_2(s)$

C $Sr^{2+}(g) + 2Cl^-(g) \rightarrow SrCl_2(s)$

D $Sr^{2+}(aq) + 2Cl^-(aq) \rightarrow SrCl_2(s)$

19. Consider the following thermochemical cycle which is not drawn to scale.



The enthalpy change for the reaction

$2H_2(g) + O_2(g) \rightarrow 2H_2O(\ell)$ is

A −564 kJ

B −282 kJ

C +564 kJ

D +1642 kJ.

20. In the presence of bright light, hydrogen and chlorine react explosively. One step in the reaction is shown below.

$H_2(g) + Cl(g) \rightarrow HCl(g) + H(g)$

The enthalpy change for this step can be represented as the bond enthalpy of

A (H—H) + (Cl—Cl)

B (H—H) – (Cl—Cl)

C (H—H) + (H—Cl)

D (H—H) – (H—Cl).

21. The standard enthalpy of atomisation of bromine is the enthalpy change for the reaction

A $\frac{1}{2}Br_2(s) \rightarrow Br(g)$

B $\frac{1}{2}Br_2(\ell) \rightarrow Br(g)$

C $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

D $Br_2(g) \rightarrow 2Br(g)$.

22. The enthalpy of solution of a compound can be calculated from its lattice enthalpy and the hydration enthalpies of its ions.

Using information from the Data Booklet, the correct value for enthalpy of solution of calcium chloride, in kJ mol^{-1}, is

A –155

B +155

C –209

D +209.

23. Which of the following reactions would show the greatest decrease in entropy?

A $H_2(g) + F_2(g) \rightarrow 2HF(g)$

B $KNO_3(s) \rightarrow KNO_2(s) + \frac{1}{2}O_2(g)$

C $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow H_2O(\ell) + CO_2(g)$

D $CO_3^{2-}(aq) + CO_2(g) + H_2O(\ell) \rightarrow 2HCO_3^-(aq)$

24. Which of the following alcohols would have the greatest entropy at 90 °C?

A Propan-1-ol

B Propan-2-ol

C Butan-1-ol

D Butan-2-ol

25. Which of the following redox equations represents a reaction which is not feasible under standard conditions?

A $F_2(g) + 2Cl^-(aq) \rightarrow 2F^-(aq) + Cl_2(g)$

B $Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(\ell)$

C $F_2(g) + 2Br^-(aq) \rightarrow 2F^-(aq) + Br_2(\ell)$

D $I_2(s) + 2Br^-(aq) \rightarrow 2I^-(aq) + Br_2(\ell)$

26. Propene can be produced by heating 1-bromopropane with ethanolic potassium hydroxide.

This reaction is an example of

A reduction

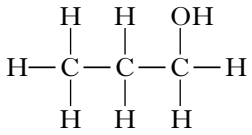
B hydrolysis

C elimination

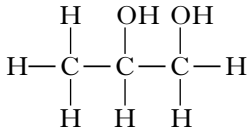
D condensation.

27. The structures of three alcohols, **P**, **Q**, and **R** are shown.

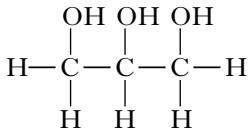
P



Q



R



Which line in the table describes correctly the trends in boiling points and viscosities on moving from **P** to **Q** to **R**?

	Boiling point	**Viscosity**
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

28. Which of the following best describes the bonding in ethane?

A sp^2 hybridisation of the carbon atoms giving sigma bonds only

B sp^2 hybridisation of the carbon atoms giving sigma and pi bonds

C sp^3 hybridisation of the carbon atoms giving sigma bonds only

D sp^3 hybridisation of the carbon atoms giving sigma and pi bonds

29. Part of a possible chain reaction mechanism for chlorine reacting with methane is:

$Cl_2 \rightarrow 2Cl\bullet$

$Cl\bullet + CH_4 \rightarrow HCl + CH_3\bullet$

$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$

Which of the following will **not** be a termination step in this reaction?

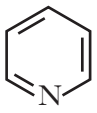
A $H\bullet + Cl\bullet \rightarrow HCl$

B $Cl\bullet + Cl\bullet \rightarrow Cl_2$

C $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$

D $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$

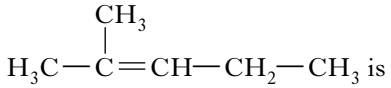
30. Pyridine, C_5H_5N, has the following structure:



Which line in the table shows the correct numbers of σ and π bonds in a molecule of pyridine?

	Number of σ bonds	**Number of π bonds**
A	3	11
B	6	3
C	11	3
D	12	3

31. The major product in the reaction of HCl with 2-methylpent-2-ene,



is

A 2-chloro-2-methylpentane

B 3-chloro-2-methylpentane

C 2,3-dichloro-2-methylpentane

D 4-chloro-4-methylpentane.

[Turn over

32. A compound, **X**, reacts with the product of its own oxidation to form an ester.

X could be

A propanal

B propan-1-ol

C propan-2-ol

D propanoic acid.

33. Which of the following amines does **not** have hydrogen bonds between its molecules in the liquid state?

A $CH_3CH_2CH_2CH_2NH_2$

B $CH_3CH_2NHCH_2CH_3$

C $(CH_3)_2CHCH_2NH_2$

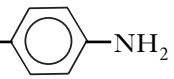
D $(CH_3)_2NCH_2CH_3$

34. 1 mole of which of the following compounds would react with the largest volume of 1 mol l^{-1} hydrochloric acid?

A CH_3NHCH_3

B $H_2NCH_2NH_2$

C $CH_2OHCHOHCH_2OH$

D 

35. The conversion of benzene to monochlorobenzene using $Cl_2/FeCl_3$ involves

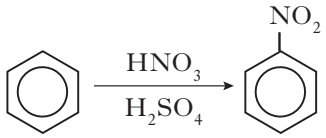
A nucleophilic addition

B nucleophilic substitution

C electrophilic addition

D electrophilic substitution.

36.



Which species initially attacks the benzene molecule in the above reaction?

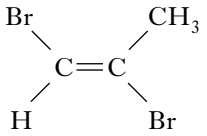
A NO_3^-

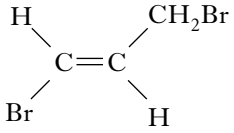
B NO_2^+

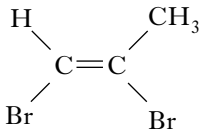
C HSO_4^-

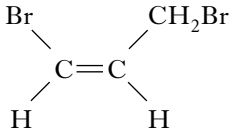
D NO_2

37. Which of the following is the geometric isomer of *trans*-1,2-dibromopropene?

A 

B 

C 

D 

38. The mass spectrum of an organic compound, empirical formula C_2H_4O, shows a peak for the parent ion at mass/charge ratio of 88.

The organic compound could **not** be

A ethanal

B butanoic acid

C ethyl ethanoate

D methyl propanoate.

39. From which region of the electromagnetic spectrum is energy absorbed in the production of proton nmr spectra?

A X-rays

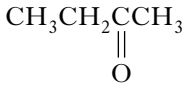
B Visible

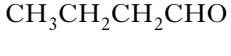
C Infra-red

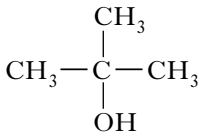
D Radio waves

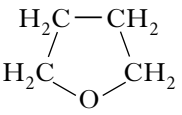
40. A compound, which has molecular formula C_4H_8O, has only 2 peaks in its low resolution proton nmr spectrum.

A possible structural formula for this compound is

A 

B 

C 

D 

[*END OF SECTION A*]

Candidates are reminded that the answer sheet for Section A MUST be placed INSIDE the front cover of your answer book.

[Turn over for SECTION B on *Page ten*

SECTION B

Marks

60 marks are available in this section of the paper.

All answers must be written clearly and legibly in ink.

1. The compound, $Sn_2Ba_2(Sr_{0\cdot5}Y_{0\cdot5})Cu_3O_8$, has zero electrical resistance at 85 K.

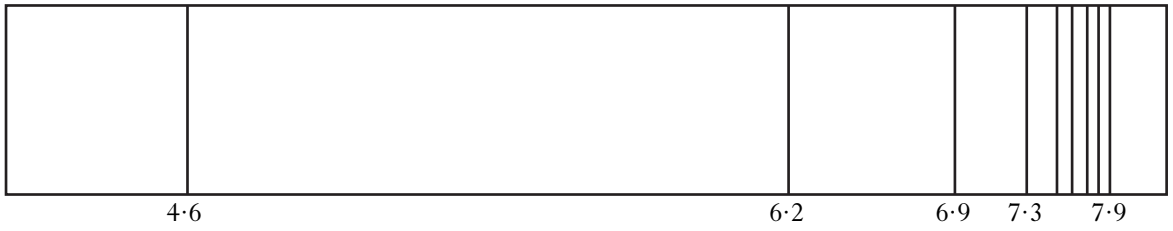
(*a*) What name is given to this phenomenon? **1**

(*b*) Which liquid coolant can be used economically and safely at this temperature? **1**

(2)

2. When hydrogen is subjected to a high voltage in a gas discharge tube and the emitted light is passed through a prism the atomic emission spectrum produced is as shown below.

hydrogen emission spectrum (visible region)



Frequency $\nu/10^{14}$ Hz

(*a*) Which line in the spectrum is red? **1**

(*b*) The ionisation energy of hydrogen has a value of 1311 kJ mol^{-1}.

(i) Write the equation for the ionisation energy of hydrogen. **1**

(ii) Calculate the wavelength of the light corresponding to this ionisation energy. **3**

(5)

Marks

3. When a mixture of nitrogen monoxide and nitrogen dioxide is cooled to –20 °C they react to form the clear blue liquid, dinitrogen trioxide.

$$NO + NO_2 \rightarrow N_2O_3$$

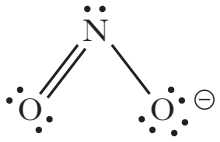
(*a*) The oxidation state of nitrogen is **different** in each of these three compounds.

Calculate the oxidation states of the nitrogen in NO and NO_2 respectively. **1**

(*b*) Dinitrogen trioxide neutralises aqueous sodium hydroxide forming sodium nitrite and water.

The nitrite ion, NO_2^-, can be represented by two resonance structures.

One of these is



Draw the other resonance structure. **1**

(*c*) In aqueous solution the nitrite ion can be oxidised to the nitrate ion.

Write the ion-electron equation for this oxidation. **1**

(3)

[Turn over

Marks

4. Iron and manganese are transition metals which have many uses in industry.

The electronic configuration for iron, in its ground state, is

$$1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$$

(*a*) In terms of s, p and d orbitals write down the electronic configurations of

(i) Fe^{3+}

(ii) Mn^{3+}

in their ground states. **2**

(iii) Explain why the Fe^{3+} ion is more stable than the Mn^{3+} ion. **1**

(*b*) The transition metal titanium is the seventh most abundant element in the Earth's crust.

Two of the reactions involved in the conversion of the ore ilmenite, $FeTiO_3$, into metallic titanium are shown below.

Step 1—Ilmenite is reacted with concentrated sulphuric acid.

$$FeTiO_3(s) + 3H_2SO_4(\ell) \longrightarrow FeSO_4(aq) + Ti(SO_4)_2(aq) + 3H_2O(\ell)$$

Step 2—After separation the titanium sulphate is reacted with sodium hydroxide.

$$Ti(SO_4)_2(aq) + 4NaOH(aq) \longrightarrow TiO_2(s) + 2H_2O(\ell) + 2Na_2SO_4(aq)$$

How many kilograms of titanium oxide can theoretically be produced from 3·25 kg of ilmenite? **2**

(*c*) Transition metals can form a wide variety of complexes. One such complex is ammonium tetrachlorocuprate(II).

Write the formula for this complex. **1**

(6)

Marks

5. The PPA "Complexometric Determination of Nickel using EDTA" has two main stages.

Stage 1 Preparation of nickel(II) sulphate solution.

Stage 2 Titration of the nickel(II) sulphate solution with EDTA.

The instructions for **Stage 1** are shown below.

1. Accurately weigh out approximately 2·6 g of hydrated nickel(II) sulphate, $NiSO_4.6H_2O$.
2. Transfer the hydrated nickel salt to a 100 cm^3 beaker, add 25 cm^3 of deionised water and stir to dissolve the solid.
3. Transfer the solution to a 100 cm^3 standard flask.
4.
5.
6. Stopper the flask and invert it several times to ensure the contents are thoroughly mixed.

(*a*) Complete the instructions for steps 4 and 5. **1**

(*b*) In **Stage 2**, 25·0 cm^3 of the nickel(II) sulphate solution were titrated against 0·110 $mol\,l^{-1}$ EDTA solution.

The results of the titrations are shown below

	Rough titre	**1st titre**	**2nd titre**
Initial burette reading/cm^3	2·00	25·90	10·00
Final burette reading/cm^3	25·90	49·40	33·60
Volume of EDTA added/cm^3	23·90	23·50	23·60

The equation for the reaction is represented by

$$Ni^{2+}(aq) + [EDTA]^{4-}(aq) \longrightarrow Ni[EDTA]^{2-}(aq)$$

(i) Name the indicator used to detect the end-point of the titration in this PPA. **1**

(ii) EDTA acts as a hexadentate ligand. What shape is the complex ion $Ni[EDTA]^{2-}$? **1**

(iii) The accurate mass of the nickel(II) sulphate used was 2·656 g.

Calculate the percentage by mass of nickel present in the hydrated salt from these experimental results. **3**

(6)

[Turn over

Marks

6. The standard free energy change for a chemical reaction is given by the expression

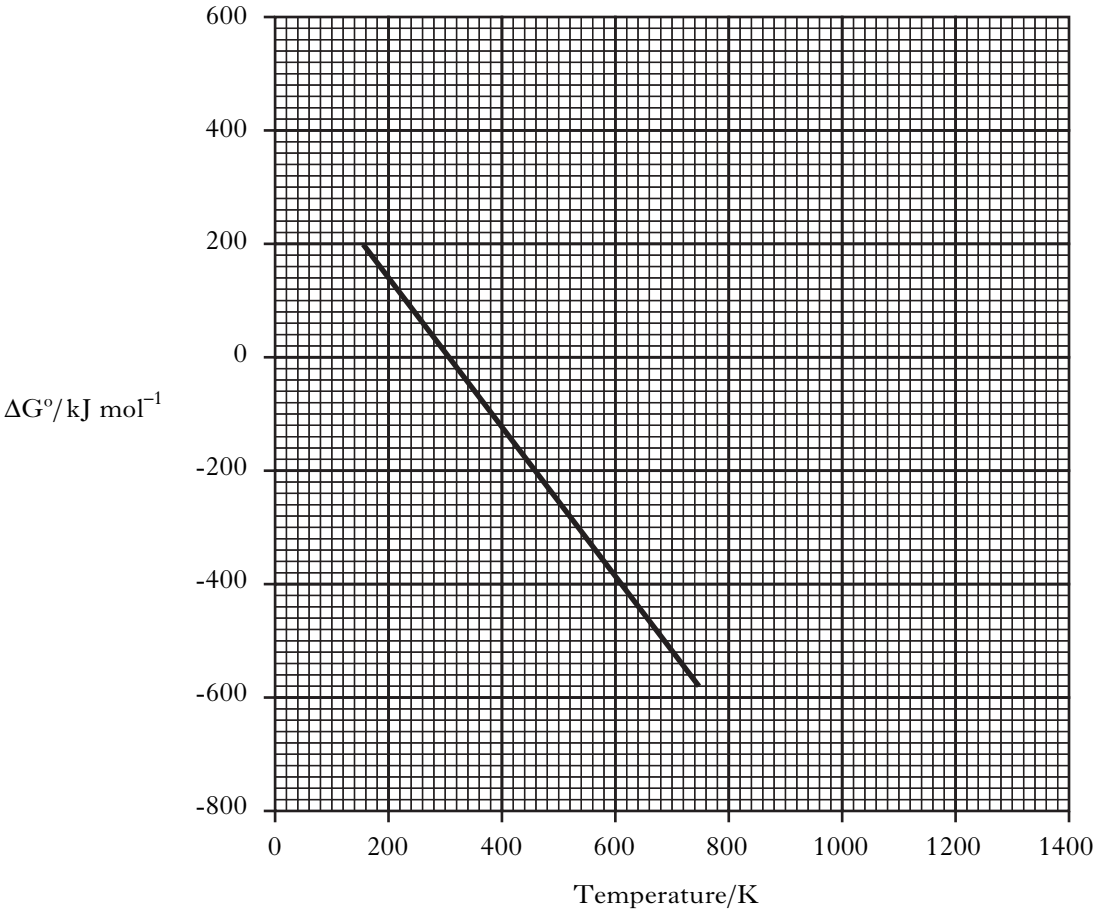
$$\Delta G^o = \Delta H^o - T\Delta S^o$$

The expression can be rearranged to give

$$\Delta G^o = -\Delta S^o T + \Delta H^o$$

Plotting values of ΔG^o against T will therefore produce a straight line with gradient equal to $-\Delta S^o$.

The graph shows how ΔG^o varies with temperature for a particular chemical reaction.



Use the graph to

(*a*) deduce the temperature at which the reaction just becomes feasible under standard conditions **1**

(*b*) estimate the value of ΔH^o, in kJ mol^{-1}, for the reaction **1**

(*c*) calculate the value of ΔS^o, in J K^{-1} mol^{-1}. **2**

(4)

Marks

7. Consider the three reactions and their rate equations

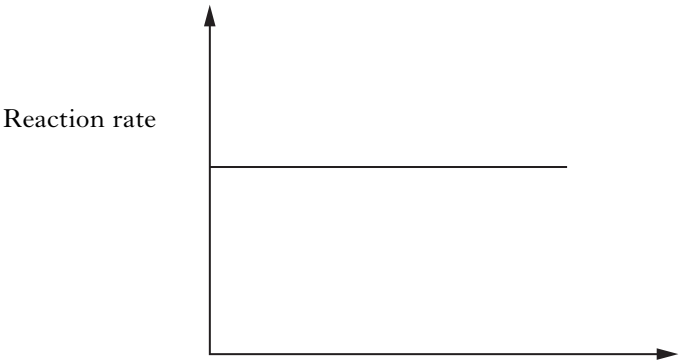
Reaction (1) $2N_2O_5 \longrightarrow 4NO_2 + O_2$ Rate = $k[N_2O_5]$

Reaction (2) $2NO + Cl_2 \longrightarrow 2NOCl$ Rate = $k[NO]^2[Cl_2]$

Reaction (3) $2NH_3 \longrightarrow N_2 + 3H_2$ Rate = $k[NH_3]^0$

(*a*) What is the overall order of Reaction (2)? **1**

(*b*) The graph below was plotted using experimental results from one of the reactions.



Explain which of the reactions would give this graph. **1**

(*c*) For Reaction (2), when the concentrations of NO and Cl_2 are both 0·250 mol l^{-1}, the initial reaction rate is $1{\cdot}43 \times 10^{-6}$ mol l^{-1} s^{-1}.

Use this information to calculate the rate constant, k, including the appropriate units. **2**

(4)

8. The reaction between hydrogen peroxide and potassium bromide is used to generate bromine to disinfect water supplies.

The ion-electron equations involved in this reaction are

$Br_2(\ell) + 2e^- \longrightarrow 2Br^-(aq)$ $E^o = 1{\cdot}07$ V

$H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O(\ell)$ $E^o = 1{\cdot}77$ V

(*a*) Write the redox equation for the reaction. **1**

(*b*) Calculate the standard free energy change, in kJ mol^{-1}, for this reaction. **3**

(4)

[Turn over

Marks

9. Buffer solutions are important in human biochemistry.

(*a*) What is meant by a "buffer solution"? **1**

(*b*) Suggest the name of a salt which could be mixed with propanoic acid to prepare an acidic buffer solution. **1**

(*c*) The pH of an alkaline buffer solution can be found using the formula

$$pH = pK_w - pK_b + \log \frac{[base]}{[salt]}$$

where K_w is the ionic product of water

and K_b is the dissociation constant of the base.

1·05 g of ammonium nitrate, NH_4NO_3, is dissolved in 100 cm^3 of a 0·15 $mol\,l^{-1}$ ammonia solution at 25 °C.

Calculate the pH of this buffer solution given that the pK_b for ammonia is 4·76. **3**

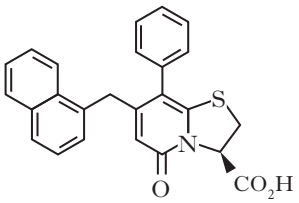
(5)

10. Chemists are developing compounds which block the ability of certain bacteria to bind to the surface of cells. This will help stop the spread of infection.

(*a*) What name is given to the structural fragment of this type of compound which binds to a receptor? **1**

(*b*) The diagram shows the structure of four of these compounds.

(1)



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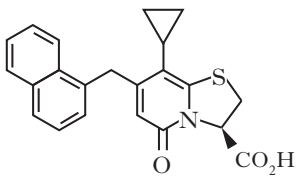

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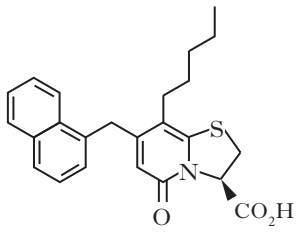
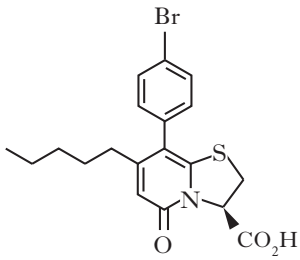


(4)



Draw the structural fragment which is common to these compounds which allows them to bind to the relevant receptor. **1**

(2)

Marks

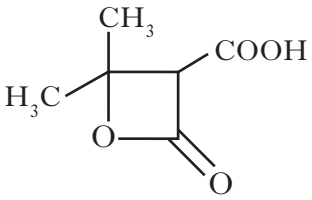
11. Meldrum's acid is a chemical named after the Scotsman, Andrew N. Meldrum who was the first to produce it.

Microanalysis showed that Meldrum's acid has a composition, by mass, of 50% C, 5·6% H, 44·4% O.

(*a*) Use the percentage composition to calculate the empirical formula of Meldrum's acid.

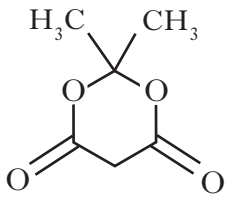
(Working must be shown) **1**

(*b*) Meldrum initially thought the structure was



Compound A

The structure was later shown to be the isomer of **A** shown below.



Compound B

(i) What is the molecular formula of **A** and **B**? **1**

(ii) The infra-red spectrum of isomer **A** would show a strong absorbance not shown by isomer **B**.

Identify the wave number range, in cm^{-1}, where this absorbance occurs. **1**

(3)

[Turn over

Marks

12. Cinnamaldehyde is an aromatic compound found in cinnamon. It can also be prepared by the reaction of benzaldehyde and ethanal.

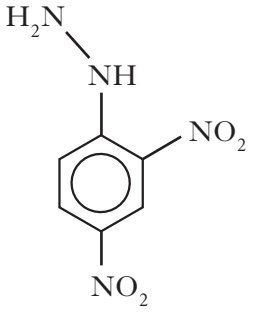
$$C_6H_5CHO + CH_3CHO \rightarrow C_6H_5CHCHCHO$$

(*a*) What type of reaction is this? **1**

(*b*) Draw a full structural formula for cinnamaldehyde. **1**

(*c*) All three of the carbonyl compounds shown above react with 2,4-dinitrophenylhydrazine, (Brady's reagent), forming solid derivatives.

The structure of 2,4-dinitrophenylhydrazine is



(i) Draw a structural formula of the compound formed when ethanal reacts with 2,4-dinitrophenylhydrazine. **1**

(ii) The compound formed is impure.

How would this compound be purified? **1**

(iii) How would the purified compound be used to show that the original carbonyl compound was ethanal? **1**

(iv) 2,4-Dinitrophenylhydrazone derivatives have distinctive colours.

What colour is the 2,4-dinitrophenylhydrazone derivative of propanone? **1**

(6)

13. When sodium hydroxide solution was added to 2-bromomethylpropane an S_N1 reaction took place producing methylpropan-2-ol and hydrobromic acid.

(*a*) (i) What is meant by an S_N1 reaction? **2**

(ii) Draw the structure of the carbocation intermediate formed in this reaction. **1**

(*b*) Chloromethane reacts with sodium ethoxide in an S_N2 reaction.

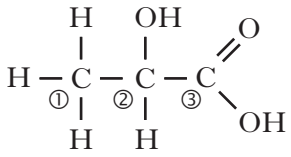
(i) How is sodium ethoxide prepared in the laboratory? **1**

(ii) Name the organic product of this S_N2 reaction. **1**

(5)

Marks

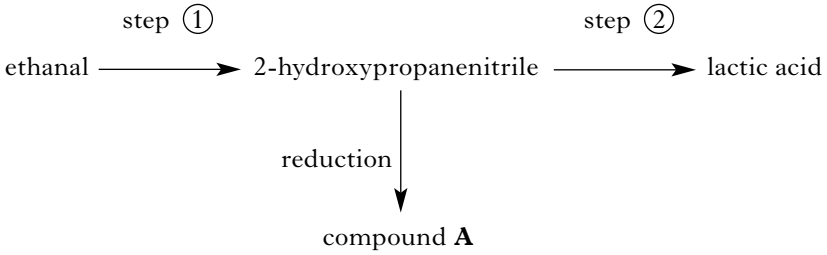
14. The structure of lactic acid is



(*a*) What is the systematic name of lactic acid? **1**

(*b*) Lactic acid contains an asymmetric carbon atom.
Identify, and **explain**, which one of the numbered carbon atoms is asymmetric. **1**

(*c*) Lactic acid can be produced from ethanal by the reaction sequence below.



(i) Which reagent could be used in step ① ? **1**

(ii) What type of reaction takes place in step ② ? **1**

(iii) Draw a structure for compound **A**. **1**

(5)

[*END OF QUESTION PAPER*]

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2011 Chemistry

Advanced Higher

Finalised Marking Instructions

Chemistry Advanced Higher

General information for markers

The general comments given below should be considered during all marking.

1 Marks should **not** be deducted for incorrect spelling or loose language as long as the meaning of the word(s) is conveyed.

Example: Answers like 'distilling' (for 'distillation') and 'it gets hotter' (for 'the temperature rises') should be accepted.

2 A right answer followed by a wrong answer should be treated as a cancelling error and no marks should be given.

Example: What is the colour of universal indicator in acid solution?

The answer 'red, blue' gains no marks.

3 If a right answer is followed by additional information which does not conflict, the additional information should be ignored, whether correct or not.

Example: Why can the tube not be made of copper?

If the correct answer is related to a low melting point, and the candidate's answer is 'It has a low melting point and is coloured grey' this would **not** be treated as a cancelling error.

4 Full marks should be awarded for the correct answer to a calculation on its own whether or not the various steps are shown **unless the question is structured or working is specifically asked for.**

5 A mark should be deducted in a calculation for each arithmetic slip **unless stated otherwise in the marking scheme.** No marks should be deducted for incorrect or missing units at intermediate stages in a calculation.

6 A mark should be deducted for incorrect or missing units **unless stated otherwise in the marking scheme**. Please note, for example, that KJ mol^{-1} is not acceptable for kJ mol^{-1} and a mark should be deducted.

7 Where a wrong numerical answer (already penalised) is carried forward to another step, no further penalty is incurred provided the result is used correctly.

8 No mark is given for the solution of an equation which is based on a wrong principle.

Example: Use the information in the table to calculate the standard entropy change for the reaction:

$$C_2H_2 + 2HCl \longrightarrow CH_2ClCH_2Cl$$

Compound	**S^o/J K^{-1} mol^{-1}**
C_2H_2	201
HCl	187
CH_2ClCH_2Cl	208

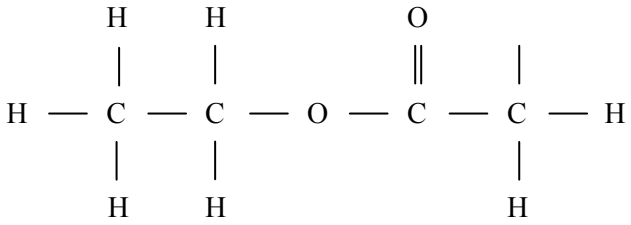
Using $\Delta S^o = S^o_{\text{reactants}} - S^o_{\text{products}}$ would gain zero marks.

9 No marks are given for the description of the wrong experiment.

10 Full marks should be given for correct information conveyed by a sketch or diagram in place of a written description or explanation.

11 In a structural formula, if one hydrogen atom is missing but the bond is shown, no marks are deducted.

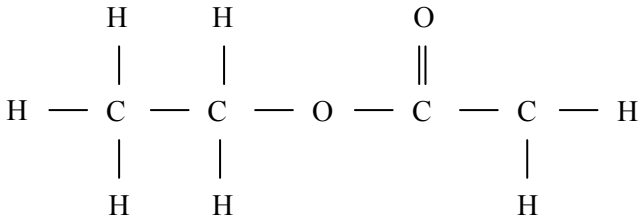
Examples:



Would not be penalised as the structural formula for ethyl ethanoate.

If the bond is also missing, then zero marks should be awarded.

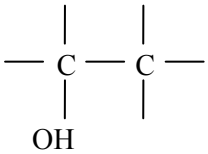
Example:



12 If a structural formula is asked for, CH_3- and CH_3CH_2- are acceptable as methyl and ethyl groups respectively.

13 With structures involving an –OH or an $–NH_2$ group, no mark should be awarded if the 'O' or 'N' are not bonded to a carbon, ie $OH–CH_2$ and $NH_2–CH_2$.

14 When drawing structural formulae, no mark should be awarded if the bond points to the 'wrong' atom, eg



15 A symbol or correct formula should be accepted in place of a name **unless stated otherwise in the marking scheme**.

16 When formulae of ionic compounds are given as answers it will only be necessary to show ion charges if these have been specifically asked for. However, if ion charges are shown, they must be correct. If incorrect charges are shown, no marks should be awarded.

17 If an answer comes directly from the text of the question, no marks should be given.

Example: A student found that 0·05 mol of propane, C_3H_8 burned to give 82·4 kJ of energy.

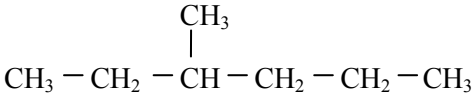
$$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$$

Name the kind of enthalpy change which the student measured.

No marks should be given for 'burning' since the word 'burned' appears in the text.

18 A guiding principle in marking is to give credit for (partially) correct chemistry rather than to look for reasons not to give marks.

Example 1: The structure of a hydrocarbon found in petrol is shown below.



Name the hydrocarbon.

Although not completely correct, the answer, '3, methyl-hexane' would gain the full mark ie wrong use of commas and dashes.

Example 2: A student measured the pH of four carboxylic acids to find out how their strength is related to the number of chlorine atoms in the molecule. The results are shown.

Structural formula	**pH**
CH_3COOH	1·65
$CH_2ClCOOH$	1·27
$CHCl_2COOH$	0·90
CCl_3COOH	0·51

How is the strength of the acids related to the number of chlorine atoms in the molecule?

Again, although not completely correct, an answer like 'the more Cl_2, the stronger the acid' should gain the full mark.

Example 3: Why does the (catalytic) converter have a honeycomb structure?

A response like 'to make it work' may be correct but it is not a chemical answer and the mark should not be given.

2011 Chemistry Advanced Higher

Marking scheme

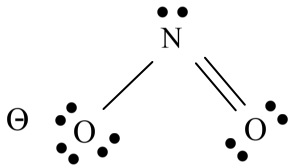
Section A

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

Section B

Question	Acceptable Answer	Mark	Unacceptable Answer
1 (a)	Superconductivity Superconducting Superconductors Superconductance	**1**	Semiconductors
(b)	Liquid nitrogen/N_2	**1**	Liquid helium or liquid oxygen N
		(2)	

Question	Acceptable Answer	Mark	Unacceptable Answer
2 (a)	The line at $4{\cdot}6 \times 10^{14}$ Hz	**1**	
(b) (i)	$H(g) \rightarrow H^+(g) + e^-$ $H(g) - e^- \rightarrow H^+(g)$	**1**	
(b) (ii)	$E = \frac{Lhc}{\lambda}$ or $E = \frac{Lhc}{1000\lambda}$	**1**	
	Wavelength, $\lambda = \frac{6{\cdot}02 \times 10^{23} \times 6{\cdot}63 \times 10^{-34} \times 3{\cdot}00 \times 10^{8}}{1311000}$	**1**	
	$= 91{\cdot}3 \times 10^{-9}$ m or 91·3 nm or $9{\cdot}13 \times 10^{-8}$m 91nm	**1**	
		(5)	

Question	Acceptable Answer	Mark	Unacceptable Answer
3 (a)	In NO, oxidation state is 2 or +2 or II 2+ In NO_2, oxidation state is 4 or +4 or IV 4+ (Both must be correct for the mark)	**1**	
(b)		**1**	Wrong number of electrons shown
(c)	$NO_2^-(aq) + H_2O(\ell) \rightarrow NO_3^-(aq) + 2H^+(aq) + 2e^-$ (state symbols not required but correct charges must be shown)	**1**	
		(3)	

Question	Acceptable Answer	Mark	Unacceptable Answer
4 (a) (i)	Fe^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$	**1**	$[Ar]3d^5$
(ii)	Mn^{3+} $1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$	**1**	$[Ar]3d^4$
(iii)	Fe^{3+} has half filled d-subshell All d-orbitals half filled	**1**	Half filled orbitals/half filled subshell Half filled d-orbitals/half filled d shell more unpaired electrons
(b)	Moles of $FeTiO_3$ = 3250/151·7 = **21·42** Mass of TiO_2 = n × FM = 21·42 × 79·9 = 1711 g = **1·71 kg**	**1** **1**	
(c)	$(NH_4)_2[Cu(Cl)_4]$	**1**	
		(6)	

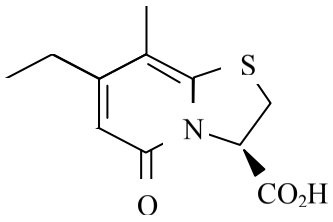
Question	Acceptable Answer	Mark	Unacceptable Answer
5 (a)	Step 4: Rinse beaker with deionised water, add washings to standard flask. Step 5: add deionised water up to mark on standard flask.	 **1**	
(b) (i)	Murexide or ammonium purpurate	**1**	
(ii)	Octahedral	**1**	
(iii)	Average titre = 23·55 cm^3 No of moles of Ni in 100 cm^3 solution = 0·02355 × 0·110 × 4 = 0·0104 % mass of Ni = $\frac{0 \cdot 0104 \times 58 \cdot 7}{2 \cdot 656} \times 100 = \mathbf{22 \cdot 98\%}$	**1** **1** **1**	
		(6)	

Question	Acceptable Answer	Mark	Unacceptable Answer
6 (a)	T = 300 K → 310 K	**1**	300 °K 300 °C
(b)	ΔH° = (+) 380 → 420 (kJ mol^{-1})	**1**	- 400
(c)	Gradient of line = -1·3 (kJ K^{-1} mol^{-1}) or ΔS° = 1·22 to 1·40 kJ K^{-1} mol^{-1}	**1**	
	ΔS° = (+) 1220 to 1400 (J K^{-1} mol^{-1})	**1**	
		(4)	

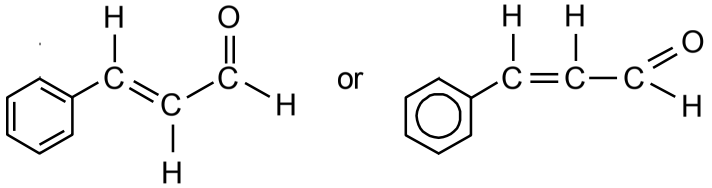
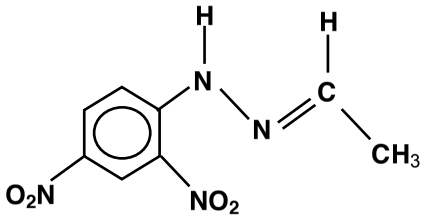
Question	Acceptable Answer	Mark	Unacceptable Answer
7 (a)	Third order/3rd/3	**1**	
(b)	Reaction 3 Rate is independent of concentration of reactants Or rate is independent of concentration of ammonia Concentration of reactant has no effect on rate	**1**	
(c)	$k = \frac{\text{Rate}}{[NO]^2[Cl_2]} = \frac{1{\cdot}43 \times 10^{-6}}{(0{\cdot}250)^2(0{\cdot}250)}$ **$= 9{\cdot}15 \times 10^{-5}$ l^2 mol^{-2} s^{-1}** **(1 mark for correct value, 1 mark for correct units)**	**2**	
		(4)	

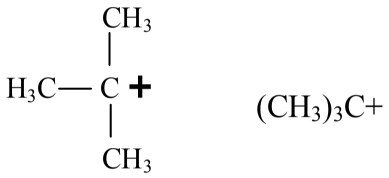
Question	Acceptable Answer	Mark	Unacceptable Answer
8 (a)	$H_2O_2(aq) + 2H^+(aq) + 2Br^-(aq) \rightarrow Br_2(\ell) + 2H_2O(\ell)$	**1**	
(b)	$\Delta G^\circ = -nFE^\circ$ $= -2 \times 96500 \times 0{\cdot}70$ $= -135{\cdot}1 \text{ kJ mol}^{-1}$ (If 0·70 given as answer (and nothing else) then award 1 mark only)	**1** **1** **1**	
		(4)	

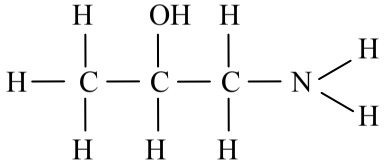
Question	Acceptable Answer	Mark	Unacceptable Answer
9 (a)	A solution in which the pH remains (approximately) constant when small amounts of acid, alkali or water are added Resists p H changes when acid/alkali added	**1**	
(b)	Sodium propanoate or potassium propanoate	**1**	
(c)	$[\text{salt}] = \frac{0 \cdot 15/80 \cdot 0}{0 \cdot 1} = 0 \cdot 131 \text{ mol l}^{-1}$ $\text{pH} = 14 - 4 \cdot 76 + \log \frac{0 \cdot 15}{0 \cdot 131}$ $\text{pH} = 14 - 4 \cdot 76 + 0 \cdot 059 =$ **9·30**	**1** **1** **1**	
		(5)	

Question	Acceptable Answer	Mark	Unacceptable Answer
10 (a)	Pharmacaphore	**1**	
(b)		**1**	
		(2)	

Question	Acceptable Answer	Mark	Unacceptable Answer
11 (a)	C H O 50 5·6 44·4 12 1 16 4·16 5·6 2·77 1·50 2·02 1 giving **$C_3H_4O_2$**	**1**	Empirical formula without any working shown
(b) (i)	$C_6H_8O_4$	**1**	
(b) (ii)	2500 – 3500 (cm^{-1}) or 1700 – 1725 cm^{-1}	**1**	
		(3)	

Question	Acceptable Answer	Mark	Unacceptable Answer
12 (a)	Condensation	**1**	elimination
(b)	 or Accept either cis/trans isomer	**1**	
(c) (i)		**1**	
(ii)	Crystallisation/recrystallisation	**1**	
(iii)	Measure melting point and compare to known data/value	**1**	Measure melting point (on its own)
(iv)	Accept yellow/orange/gold	**1**	
		(6)	

Question	Acceptable Answer	Mark	Unacceptable Answer
13 (a) (i)	Nucleophilic substitution/replacement by a nucleophile First order unimolecular	**1** **1**	
(ii)	 $(CH_3)_3C+$		
(b) (i)	Na in ethanol	**1**	
(ii)	Methoxyethane Accept methyl ethyl ether or ethylmethylether	**1**	
		(5)	

Question	Acceptable Answer	Mark	Unacceptable Answer
14 (a)	2-hydroxypropanoic acid (spelling must be correct)	**1**	
(b)	Carbon atom ② because it has 4 different groups attached	**1**	Carbon atom ② with no explanation
(c) (i)	KCN or NaCN or HCN or any cyanide compound that would work or correct names	**1**	
(ii)	Hydrolysis/acid hydrolysis	**1**	
(iii)	 or $CH_3CHOHCH_2NH_2$	**1**	
		(5)	

[END OF MARKING INSTRUCTIONS]