

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

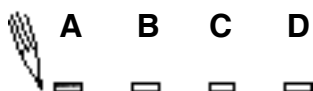
- 1 Check that the answer sheet provided is for **Chemistry Advanced Higher (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate 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

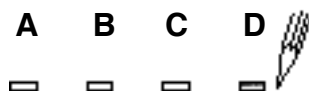
- A chromatography
- B fractional distillation
- C fractional crystallisation
- D filtration.

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

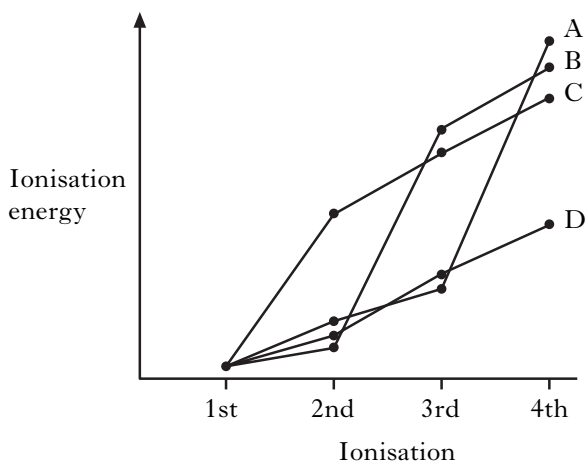


Changing an answer

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**.



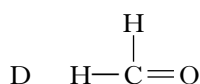
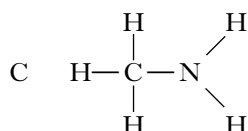
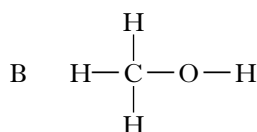
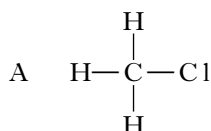
1. Which of the following lines on the graph represents the trend in successive ionisation energies of a Group 3 element?



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)?



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



- 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.

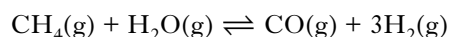
10. Which of the following ions is **least** likely to be coloured?

- A $\text{Ti}(\text{H}_2\text{O})_6^{3+}$
- B $\text{Cr}(\text{NH}_3)_6^{3+}$
- C $\text{Ni}(\text{H}_2\text{O})_6^{2+}$
- D $\text{Zn}(\text{NH}_3)_4^{2+}$

11. What volume of 0.25 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 0.1 mol l^{-1} ?

- A 50 cm^3
- B 100 cm^3
- C 200 cm^3
- D 400 cm^3

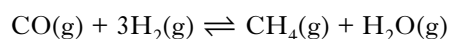
12. Hydrogen for use in ammonia production is produced by the endothermic reaction:



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



has an equilibrium constant of 3.9 at 950°C .

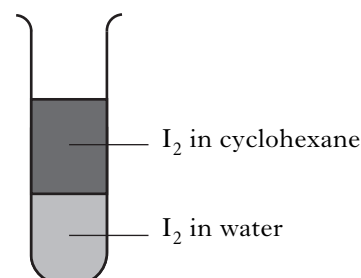
The equilibrium concentrations of $\text{CO}(\text{g})$, $\text{H}_2(\text{g})$ and $\text{H}_2\text{O}(\text{g})$ are given in the table.

Substance	Equilibrium concentration/ mol l^{-1}
$\text{CO}(\text{g})$	0.500
$\text{H}_2(\text{g})$	0.100
$\text{H}_2\text{O}(\text{g})$	0.040

What is the equilibrium concentration of $\text{CH}_4(\text{g})$, 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

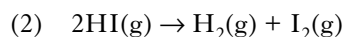
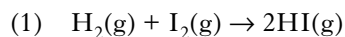
16. Under certain conditions liquid ammonia ionises as shown:



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



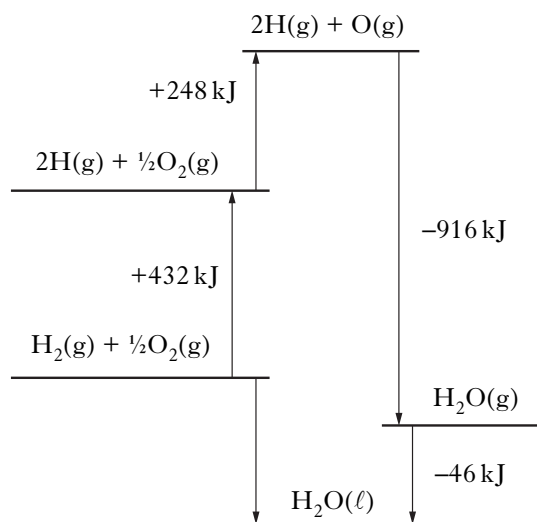
are 165 kJ and 179 kJ respectively. The enthalpy change for reaction (2) is

- A -14 kJ
 B +14 kJ
 C -344 kJ
 D +344 kJ.

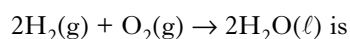
18. The standard enthalpy of formation of strontium chloride is the enthalpy change for which of the following reactions?

- A $\text{Sr}(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{SrCl}_2(\text{s})$
 B $\text{Sr}(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{SrCl}_2(\text{s})$
 C $\text{Sr}^{2+}(\text{g}) + 2\text{Cl}^-(\text{g}) \rightarrow \text{SrCl}_2(\text{s})$
 D $\text{Sr}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \rightarrow \text{SrCl}_2(\text{s})$

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



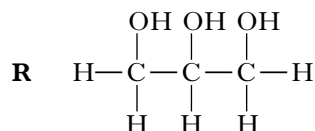
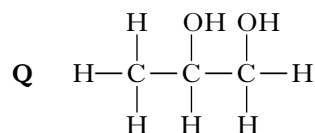
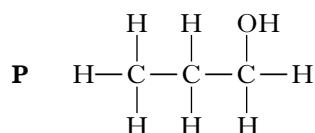
The enthalpy change for the reaction



- 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.
- $$\text{H}_2(\text{g}) + \text{Cl}(\text{g}) \rightarrow \text{HCl}(\text{g}) + \text{H}(\text{g})$$
- 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 $\frac{1}{2}\text{Br}_2(\text{s}) \rightarrow \text{Br}(\text{g})$
 B $\frac{1}{2}\text{Br}_2(\ell) \rightarrow \text{Br}(\text{g})$
 C $\frac{1}{2}\text{Br}_2(\text{g}) \rightarrow \text{Br}(\text{g})$
 D $\text{Br}_2(\text{g}) \rightarrow 2\text{Br}(\text{g})$.
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 $\text{H}_2(\text{g}) + \text{F}_2(\text{g}) \rightarrow 2\text{HF}(\text{g})$
 B $\text{KNO}_3(\text{s}) \rightarrow \text{KNO}_2(\text{s}) + \frac{1}{2}\text{O}_2(\text{g})$
 C $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\ell) + \text{CO}_2(\text{g})$
 D $\text{CO}_3^{2-}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\ell) \rightarrow 2\text{HCO}_3^-(\text{aq})$
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 $\text{F}_2(\text{g}) + 2\text{Cl}^-(\text{aq}) \rightarrow 2\text{F}^-(\text{aq}) + \text{Cl}_2(\text{g})$
 B $\text{Cl}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{Br}_2(\ell)$
 C $\text{F}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{F}^-(\text{aq}) + \text{Br}_2(\ell)$
 D $\text{I}_2(\text{s}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{I}^-(\text{aq}) + \text{Br}_2(\ell)$
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.



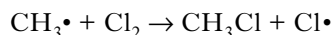
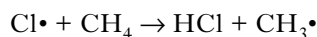
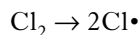
Which line in the table describes correctly the trends in boiling points and viscosities on moving from **P** to **Q** to **R**?

	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

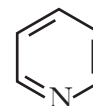
29. Part of a possible chain reaction mechanism for chlorine reacting with methane is:



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

- A $\text{H}\cdot + \text{Cl}\cdot \rightarrow \text{HCl}$
 B $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2$
 C $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{C}_2\text{H}_6$
 D $\text{CH}_3\cdot + \text{Cl}\cdot \rightarrow \text{CH}_3\text{Cl}$

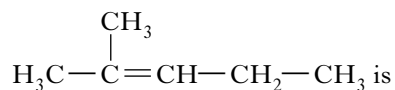
30. Pyridine, $\text{C}_5\text{H}_5\text{N}$, has the following structure:



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,



- 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

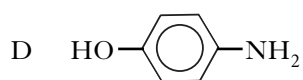
- A propanal
- B propan-1-ol
- C propan-2-ol
- D propanoic acid.

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

- A $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$
- B $\text{CH}_3\text{CH}_2\text{NHCH}_2\text{CH}_3$
- C $(\text{CH}_3)_2\text{CHCH}_2\text{NH}_2$
- D $(\text{CH}_3)_2\text{NCH}_2\text{CH}_3$

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

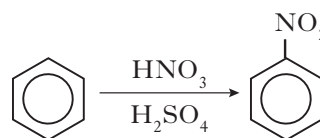
- A CH_3NHCH_3
- B $\text{H}_2\text{NCH}_2\text{NH}_2$
- C $\text{CH}_2\text{OHCHOHCH}_2\text{OH}$



35. The conversion of benzene to monochlorobenzene using $\text{Cl}_2/\text{FeCl}_3$ involves

- A nucleophilic addition
- B nucleophilic substitution
- C electrophilic addition
- D electrophilic substitution.

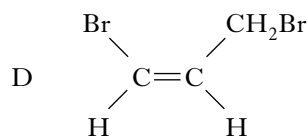
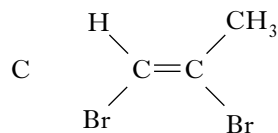
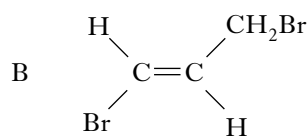
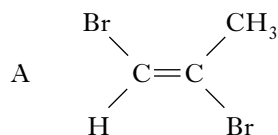
36.



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?



38. The mass spectrum of an organic compound, empirical formula $\text{C}_2\text{H}_4\text{O}$, shows a peak for the parent ion at mass/charge ratio of 88.

The organic compound could **not** be

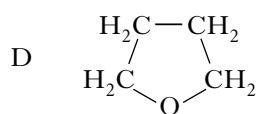
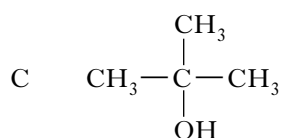
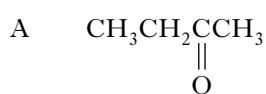
- A ethanal
- B butanoic acid
- C ethyl ethanoate
- D methyl propanoate.

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



[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, $\text{Sn}_2\text{Ba}_2(\text{Sr}_{0.5}\text{Y}_{0.5})\text{Cu}_3\text{O}_8$, has zero electrical resistance at 85 K.

(a) What name is given to this phenomenon?

1

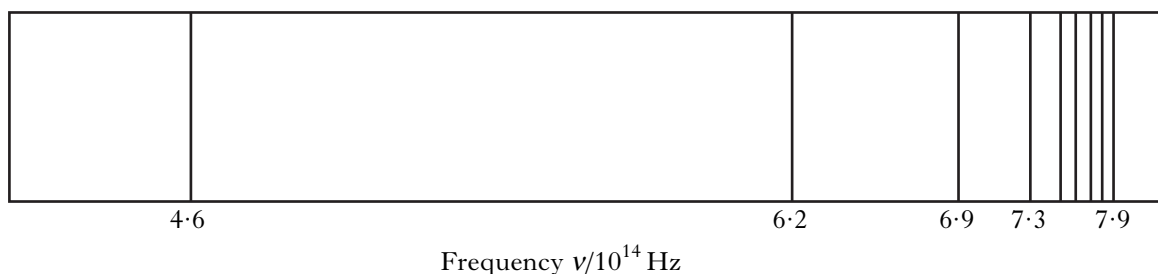
(b) Which liquid coolant can be used economically and safely at this temperature?

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)



(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.

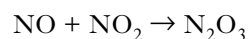
1

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

3

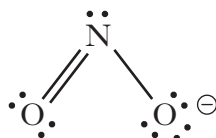
(5)

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.



- (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

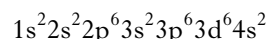
- (c) In aqueous solution the nitrite ion can be oxidised to the nitrate ion.
Write the ion-electron equation for this oxidation. 1

(3)

[Turn over

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

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



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



in their ground states.

2

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

1

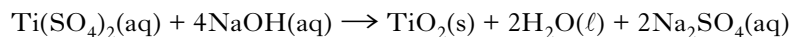
- (b) The transition metal titanium is the seventh most abundant element in the Earth's crust.

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.



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



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)

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, $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$.
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.

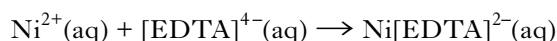
1

(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



- (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 $\text{Ni}[\text{EDTA}]^{2-}$? 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

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

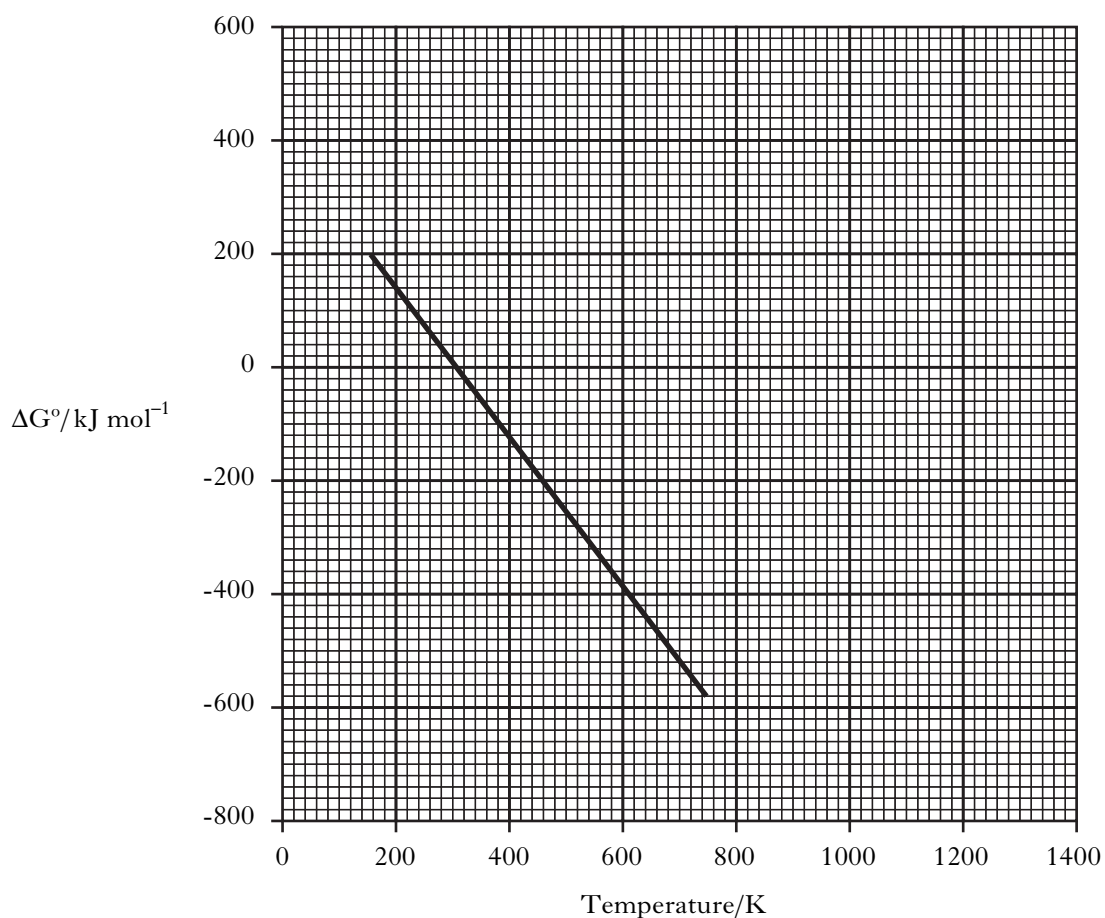
$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

The expression can be rearranged to give

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

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

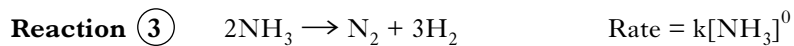
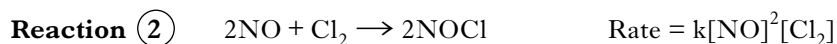
The graph shows how ΔG° varies with temperature for a particular chemical reaction.



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° , in kJ mol^{-1} , for the reaction **1**
- (c) calculate the value of ΔS° , in $\text{J K}^{-1} \text{mol}^{-1}$. **2**
- (4)**

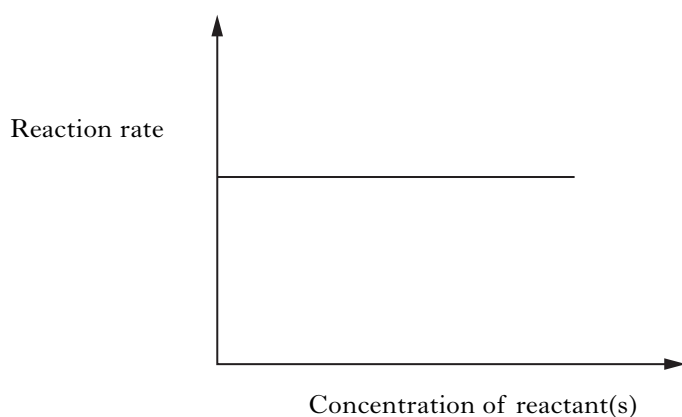
7. Consider the three reactions and their rate equations



(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 Cl₂ are both 0.250 mol l⁻¹, the initial reaction rate is 1.43 × 10⁻⁶ mol l⁻¹ s⁻¹.

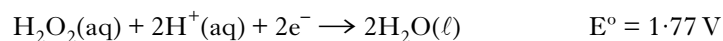
Use this information to calculate the rate constant, k, including the appropriate units.

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



(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

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

$$\text{pH} = \text{p}K_w - \text{p}K_b + \log \frac{[\text{base}]}{[\text{salt}]}$$

where K_w is the ionic product of water

and K_b is the dissociation constant of the base.

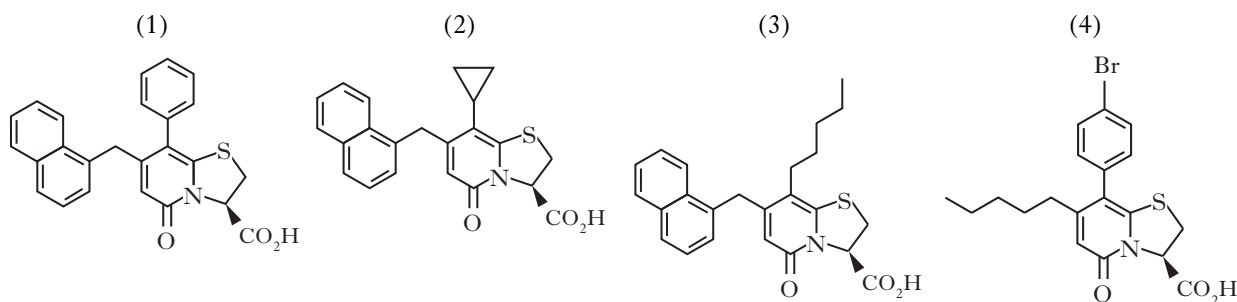
1.05 g of ammonium nitrate, NH_4NO_3 , is dissolved in 100 cm^3 of a 0.15 mol l^{-1} ammonia solution at 25°C .

Calculate the pH of this buffer solution given that the $\text{p}K_b$ 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.



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

1
(2)

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

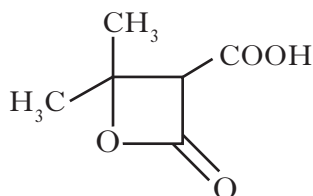
Microanalysis showed that Meldrum's acid has a composition, by mass, of 50% C, 5.6% H, 44.4% O.

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

(Working must be shown)

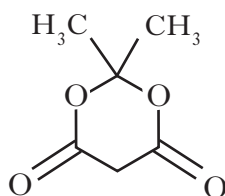
1

- (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)

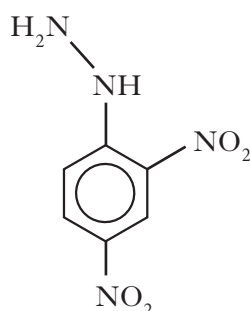
[Turn over

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



- (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

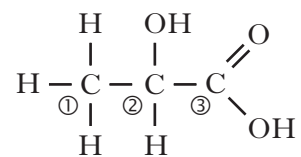


- (i) Draw a structural formula of the compound formed when ethanal reacts with 2,4-dinitrophenylhydrazine. 1
- (ii) The compound formed is impure.
How would this compound be purified? 1
- (iii) How would the purified compound be used to show that the original carbonyl compound was ethanal? 1
- (iv) 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 $\text{S}_{\text{N}}1$ reaction took place producing methylpropan-2-ol and hydrobromic acid.

- (a) (i) What is meant by an $\text{S}_{\text{N}}1$ reaction? 2
- (ii) Draw the structure of the carbocation intermediate formed in this reaction. 1
- (b) Chloromethane reacts with sodium ethoxide in an $\text{S}_{\text{N}}2$ reaction.
- (i) How is sodium ethoxide prepared in the laboratory? 1
- (ii) Name the organic product of this $\text{S}_{\text{N}}2$ reaction. 1
- (5)**

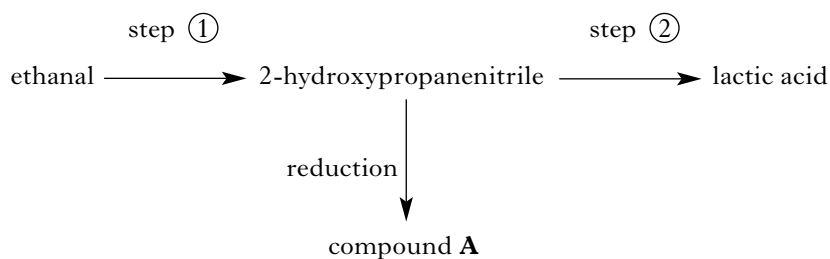
14. The structure of lactic acid is



(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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