

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Monday 20 May 2019 – Morning

AS Level Chemistry A

H032/01 Breadth in chemistry

**Time allowed: 1 hour 30 minutes
plus your additional time allowance**

**YOU MUST HAVE:
the Data Sheet for Chemistry A**

**YOU MAY USE:
a scientific or graphical calculator
a model for Q21 (d)(iii)**

Please write clearly in black ink.

Centre number

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Candidate number

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First name(s) _____

Last name _____

READ INSTRUCTIONS OVERLEAF



INSTRUCTIONS

Use black ink. HB pencil may be used for graphs and diagrams only.

Answer ALL the questions.

Where appropriate, your answers should be supported with working. Marks may be given for a correct method even if the answer is incorrect.

Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION

The total mark for this paper is 70.

The marks for each question are shown in brackets [].

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SECTION A

You should spend a maximum of 25 minutes on this section.

Answer ALL the questions.

Write your answer to each question in the box provided.

- 1 Which statement about the periodic table is NOT correct? [1]**
- A The elements are arranged in groups with similar chemical properties.**
 - B The elements are arranged in periods with repeating trends in properties.**
 - C The elements are arranged in order of increasing atomic number.**
 - D The elements in the halogen group increase in reactivity down the group.**

Your answer

2 Which molecule contains the largest bond angle? [1]



Your answer

3 What is the percentage composition by mass of nitrogen in $(\text{NH}_4)_2\text{CO}_3$? [1]

A 14.58%

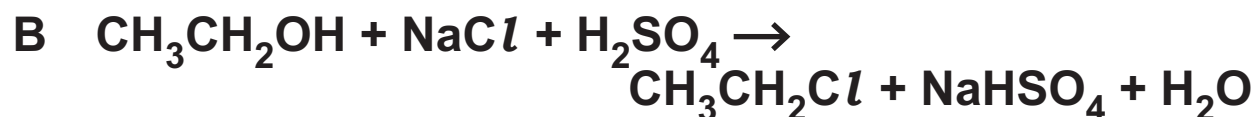
B 17.95%

C 29.17%

D 37.50%

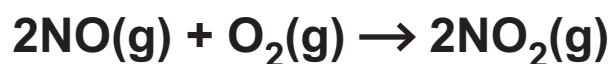
Your answer

4 Which chemical process is the most sustainable in terms of the atom economy of the organic product? [1]



Your answer

5 8.0 dm^3 of NO is mixed with 6.0 dm^3 of O_2 at room temperature and pressure (RTP).
The reaction below takes place until one of the reactants is used up.



What is the volume of the mixture at RTP after the reaction has taken place? [1]

A 8.0 dm^3

B 10.0 dm^3

C 12.0 dm^3

D 14.0 dm^3

Your answer

6 What is the volume of 0.0100 mol of N_2 at 350°C and 200 kPa? [1]

A 145 cm^3

B 259 cm^3

C 145 dm^3

D 259 dm^3

Your answer

7 0.24 g of an element, X, is reacted with 0.0100 mol Cl_2 to form a chloride with the formula XCl_2 .

What is element X? [1]

A carbon

B magnesium

C molybdenum

D titanium

Your answer

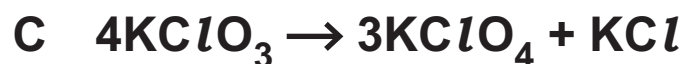
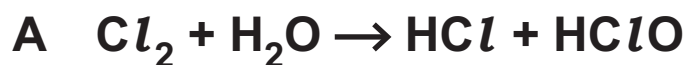
8 A phosphate(V) ion has the formula PO_4^{3-} .

What is the formula for copper(I) phosphate(V)? [1]



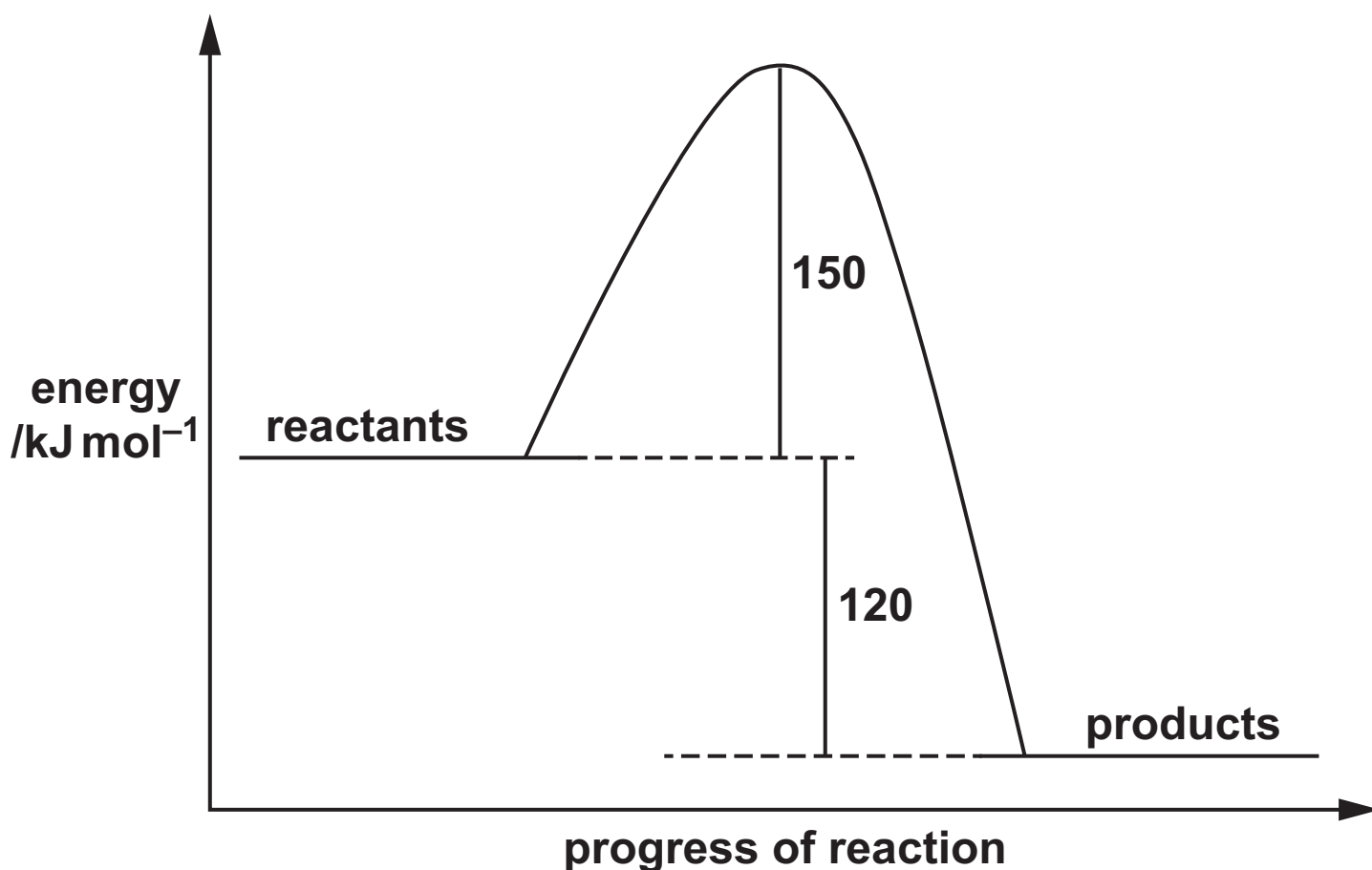
Your answer

9 Which reaction shows chlorine only being oxidised? [1]



Your answer

10 A reversible reaction has the enthalpy profile diagram shown below.



Which statement about this reaction is correct? [1]

- A The activation energy of the forward reaction is 120 kJ mol^{-1} .**
- B The activation energy of the reverse reaction is 270 kJ mol^{-1} .**
- C The enthalpy change of the forward reaction is -30 kJ mol^{-1} .**
- D The reverse reaction is exothermic.**

Your answer

☐

11 Hydrogen and chlorine react as shown below.



Which statement about this reaction is correct? [1]

- A Less energy is released on bond making than is taken in during bond breaking.**
- B The enthalpy change for the reverse equation is $+184.6 \text{ kJ mol}^{-1}$.**
- C The enthalpy change of formation of $\text{HCl}(\text{g})$ is $-184.6 \text{ kJ mol}^{-1}$.**
- D The temperature decreases during the reaction.**

Your answer

☐

12 What is the MAIN reason for the increase in reaction rate with increasing temperature? [1]

- A The activation energy decreases.**
- B The activation energy increases.**
- C More molecules have an energy greater than the activation energy.**
- D The molecules collide more frequently.**

Your answer

☐

13 A catalyst is added to a system in equilibrium.

What is the effect on the rates of the forward and reverse reactions? [1]

- A There is no effect on the rate in either direction.**
- B Both rates increase by the same factor.**
- C The rate in the forward direction increases by a greater factor than the reverse direction.**
- D The rate in the reverse direction increases by a greater factor than the forward direction.**

Your answer

☐

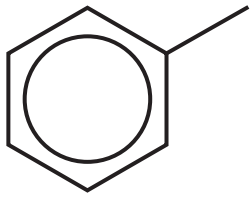
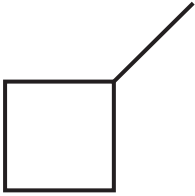
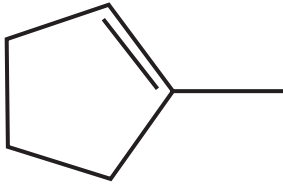
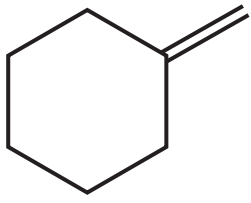
14 What is the best description for the bonding between the carbon atoms in an ethene molecule? [1]

- A One σ -bond and one π -bond**
- B One π -bond**
- C Two σ -bonds**
- D Two π -bonds**

Your answer

☐

15 Which compound is unsaturated, alicyclic and contains an alkyl group? [1]

| | |
|----------|--|
| A |  |
| B |  |
| C |  |
| D |  |

Your answer

☐

16 Which statement about an electrophile is correct? [1]

A It is an electron pair acceptor.

B It is a proton donor.

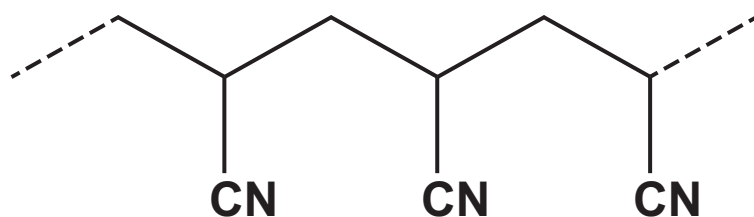
C It is a negative ion.

D It is a species with an unpaired electron.

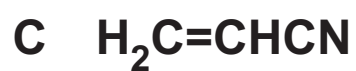
Your answer

☐

17 A section of a polymer is shown below.



Which monomer could form this polymer? [1]



Your answer

18 Which compound is NOT likely to have a fragment ion at $m/z = 43$ in its mass spectrum? [1]

| | |
|---|---|
| A | $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad // \\ \text{H}-\text{C}-\text{C}-\text{C} \\ \quad \quad \backslash \\ \text{H} \quad \text{H} \quad \text{OH} \end{array} $ |
| B | $ \begin{array}{c} \text{H} \quad \text{O} \\ \quad // \\ \text{H}-\text{C}-\text{C} \\ \quad \backslash \\ \text{H} \quad \text{OH} \end{array} $ |
| C | $ \begin{array}{c} \text{H} \quad \text{CH}_3 \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $ |
| D | $ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{OH} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $ |

Your answer

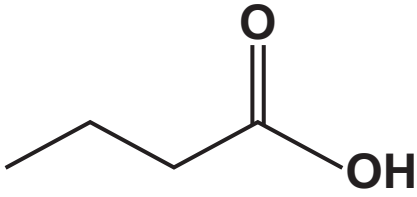
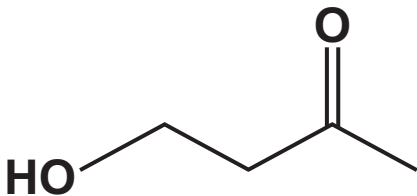
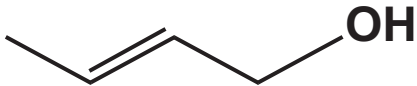
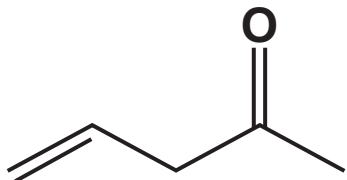
19 Which statement about infrared radiation is NOT correct? [1]

- A The energy from IR radiation causes some covalent bonds to vibrate more.**
- B Absorption of IR radiation by some atmospheric gases is linked by some scientists to global warming.**
- C IR radiation is used to monitor gases causing air pollution.**
- D The action of IR radiation on CFCs in the upper atmosphere leads to the formation of chlorine radicals.**

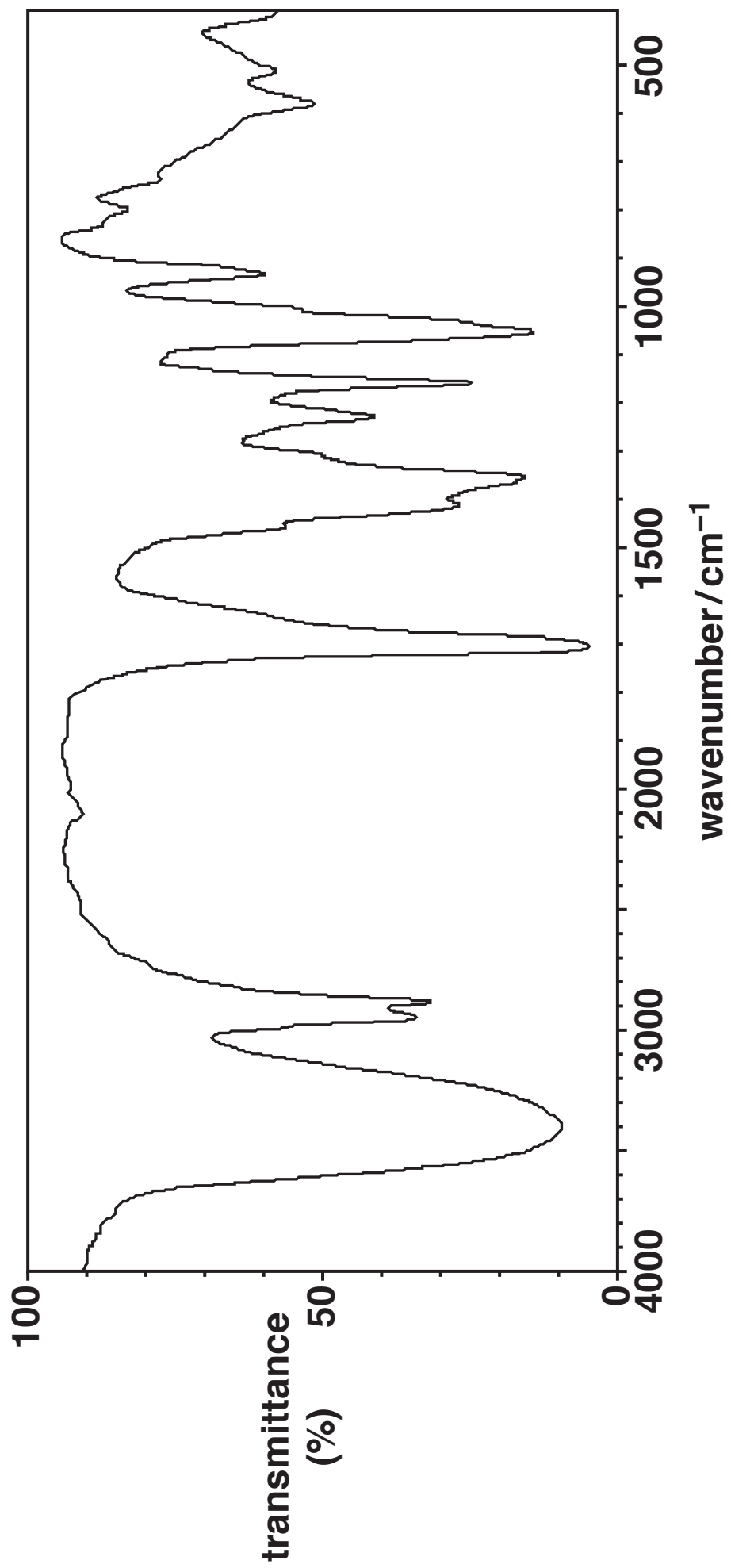
Your answer

20 An unknown compound produces the infrared spectrum on the page opposite.

Which compound could have produced the infrared spectrum? [1]

| | |
|---|---|
| A |  |
| B |  |
| C |  |
| D |  |

Your answer



SECTION B

Answer ALL the questions.

21 This question is about atomic structure and the compounds of calcium, nitrogen and oxygen.

(a) Most elements contain different isotopes.

State TWO differences between isotopes of the same element.

[1]

(b) Complete the table for an atom and an ion of two different elements. [2]

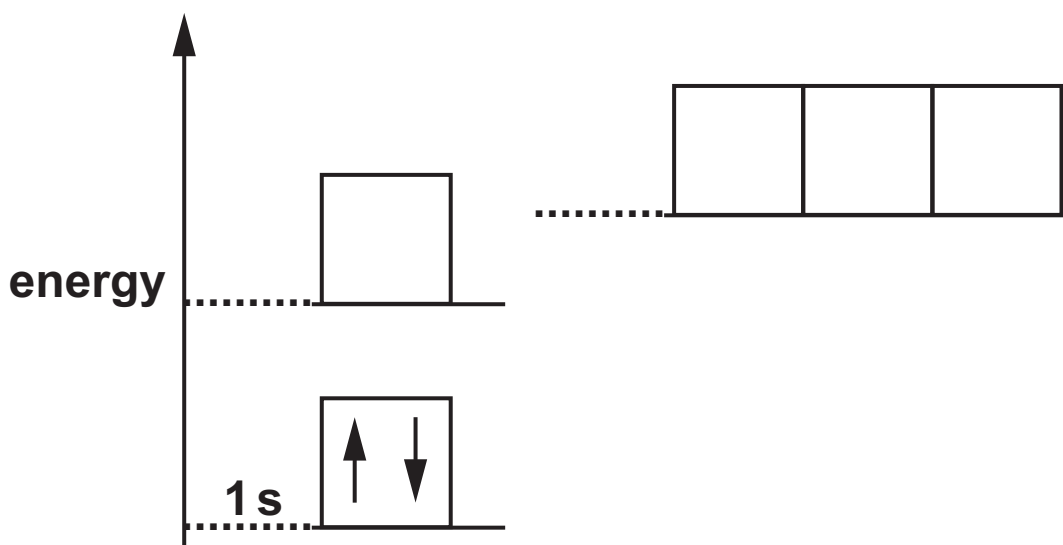
| Element | Mass number | Protons | Neutrons | Electrons | Charge |
|---------|-------------|---------|----------|-----------|--------|
| | | 26 | 28 | | 0 |
| | 80 | | | 36 | 2- |

- (c) Electrons occupy orbitals which are arranged in energy levels.

In the diagram below, each box represents an orbital and each electron is shown as an arrow.

Label the sub-shells and add arrows to show how electrons occupy orbitals in an atom of OXYGEN.

[2]



(d) Calcium reacts with nitrogen to form calcium nitride, Ca_3N_2 , which is an ionic compound.

(i) Construct a 'dot-and-cross' diagram for Ca_3N_2 .

Show outer electrons only and the charges on each ion. Use the space below. [2]

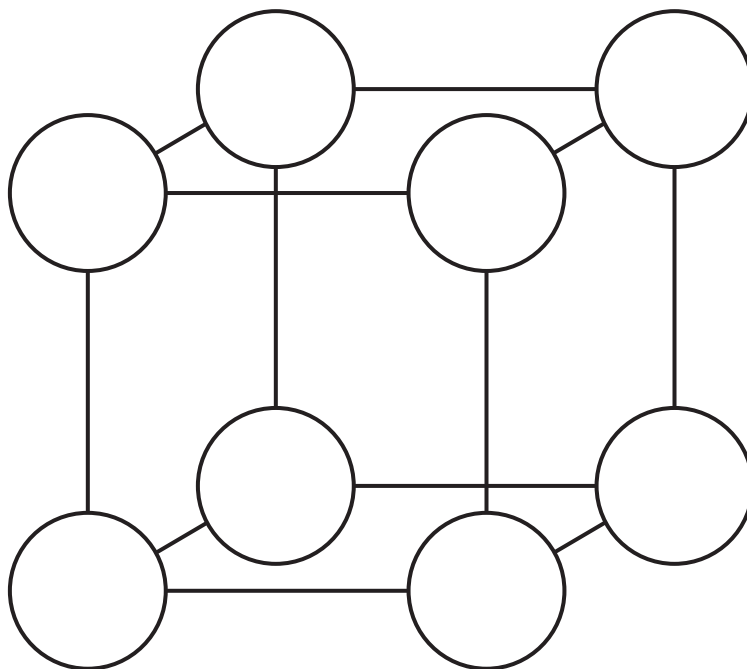
(ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds.

Write an equation for this reaction.

_____ [2]

- (iii) Calcium reacts with oxygen to form a compound which has a giant ionic lattice structure. The diagram shows ions as circles in part of the lattice.

Complete the diagram by showing the symbols of the ions, including charges. [2]



- (iv) Nitrogen forms an oxide with the formula N_2O . A molecule of N_2O is linear and has a nitrogen atom in the centre.

Draw a 'dot-and-cross' diagram for an N_2O molecule.

Show outer electrons only. [2]

- 22 A student carries out a titration to determine the concentration of some hydrochloric acid.**

The student titrates the hydrochloric acid against a standard solution of sodium carbonate, Na_2CO_3 . The equation is shown below.



The student prepares $0.150 \text{ mol dm}^{-3}$ Na_2CO_3 in a 250.0 cm^3 volumetric flask.

The hydrochloric acid is added to a 50.0 cm^3 burette.

The student pipettes the $\text{Na}_2\text{CO}_3(\text{aq})$ using a 25.0 cm^3 pipette.

- (a) The student's burette readings are shown in the table.**

THE ROUGH TITRE HAS BEEN OMITTED.

- (i) Complete the table by adding the titres to the table. [1]**

| | | | |
|---|--------------|--------------|--------------|
| Final reading / cm^3 | 24.60 | 48.45 | 34.30 |
| Initial reading / cm^3 | 0.40 | 24.60 | 10.00 |
| Titre / cm^3 | | | |

- (ii) Calculate the mean titre of HCl , to the nearest 0.05 cm^3 , that the student should use for analysing the results.

mean titre = _____ cm^3 [1]

- (b) Calculate the concentration, in mol dm^{-3} , of the hydrochloric acid.

Give your answer to 3 significant figures.

concentration of HCl = _____ mol dm^{-3} [3]

(c) In the titrations, the student measured volumes with a pipette and a burette.

The pipette had an uncertainty of $\pm 0.04 \text{ cm}^3$ in the volume measured.

The burette had an uncertainty of $\pm 0.05 \text{ cm}^3$ in the volume measured.

Determine whether the volume measured by the pipette or the volume measured by the burette has the greater percentage uncertainty. [2]

23 This question is about halogens and halides.

(a) The boiling points of the halogens are shown in the table.

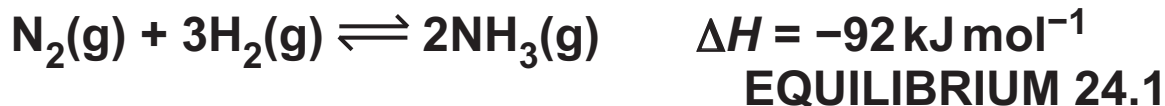
| Halogen | Boiling point /K |
|-----------------|-------------------------|
| fluorine | 85 |
| chlorine | 239 |
| bromine | 332 |
| iodine | 457 |
| astatine | 503 |

Explain the trend in boiling points of the halogens.

[3]

24 This question is about ammonia, NH₃.

- (a) In industry, ammonia is made from nitrogen and hydrogen. This is a reversible reaction, as shown in EQUILIBRIUM 24.1 below.**



- (i) Explain how le Chatelier's principle can be used to predict the conditions of temperature and pressure for a maximum EQUILIBRIUM yield of ammonia.**

[4]

- (ii) Using certain conditions, EQUILIBRIUM 24.1 has the equilibrium concentrations in the table.

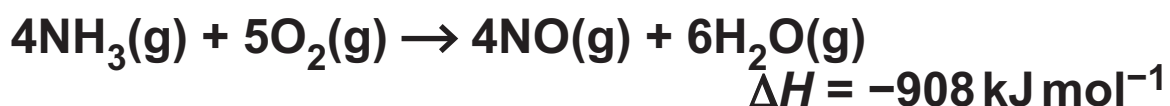
| Substance | Equilibrium concentration / mol dm ⁻³ |
|---------------------|--|
| N ₂ (g) | 1.25 |
| H ₂ (g) | 2.75 |
| NH ₃ (g) | 0.862 |

Calculate the numerical value for K_c for EQUILIBRIUM 24.1 under these conditions.

Give your answer to an APPROPRIATE number of significant figures and in STANDARD FORM.

$K_c =$ _____ [2]

- (b) Ammonia is used to make nitric acid. The first stage of the reaction is shown below.



Standard enthalpy changes of formation, $\Delta_f H^\ominus$, are given in the table.

| Substance | $\Delta_f H^\ominus / \text{kJ mol}^{-1}$ |
|--------------------------------|---|
| $\text{NH}_3(\text{g})$ | -46 |
| $\text{O}_2(\text{g})$ | 0 |
| $\text{H}_2\text{O}(\text{g})$ | -242 |

- (i) State the conditions of temperature and pressure used for standard enthalpy measurements.

Temperature _____

Pressure _____

[1]

- (ii) Calculate the standard enthalpy change of formation for NO(g).

Give your answer to a WHOLE NUMBER.

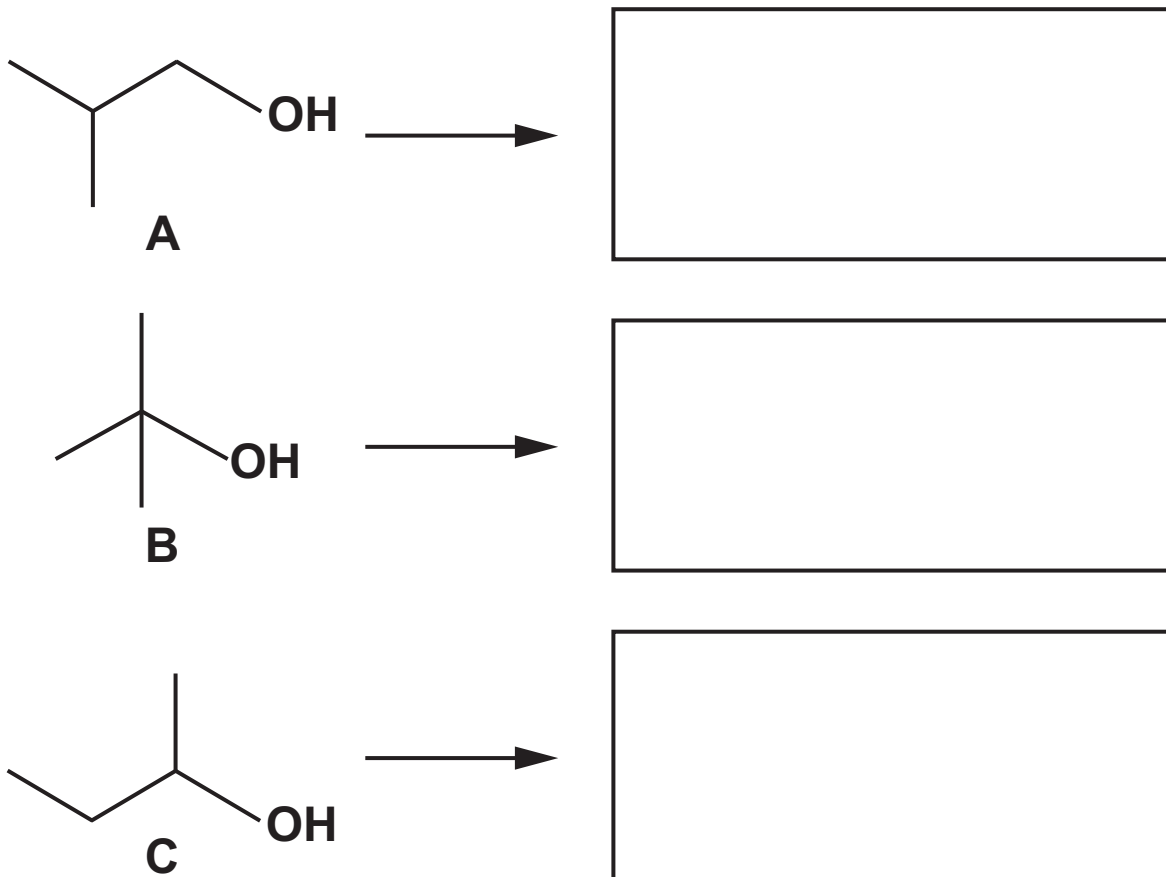
$\Delta_f H^\ominus$ for NO(g) = _____ kJ mol⁻¹ [3]

25 This question is about alcohols and alkanes.

- (a) Three alcohols A, B and C are structural isomers of $C_4H_{10}O$.**

Each alcohol is refluxed with acidified dichromate(VI), $H^+/Cr_2O_7^{2-}$.

- (i) Draw the structures for the organic products. If there is no reaction, write 'NONE'. [3]**



- (ii) Write the systematic name for alcohol C.**

_____ [1]

- (iii) Complete the equation below for the complete combustion of alcohol A.**



(b) Under suitable conditions, butane, C_4H_{10} , reacts with chlorine by radical substitution.

A mixture of organic compounds is formed, including $\text{C}_4\text{H}_9\text{Cl}$, and compounds D and E.

- (i) Complete the table below to show the mechanism for the initiation and propagation stages of the reaction of C_4H_{10} with chlorine to form $\text{C}_4\text{H}_9\text{Cl}$.

In your equations, use molecular formulae and 'dots' (\bullet) with any radicals. [3]

| | |
|-------------|---|
| Initiation | Equation _____ Conditions _____ |
| Propagation | _____ _____ \rightarrow _____ _____ \rightarrow _____ |

- (ii) Organic compound D is formed by substitution of ALL the H atoms in butane by Cl atoms.

Write the equation for the formation of compound D from butane.

Use molecular formulae.

_____ [1]

- (iii) Organic compound E is formed by the substitution of **SOME** of the H atoms in butane by **Cl** atoms.

A chemist found that 0.636 g of compound E has a volume of 78.0 cm^3 .

Under the conditions used, the molar gas volume is $32.5\text{ dm}^3\text{ mol}^{-1}$.

Determine the molecular formula of compound E.

molecular formula = _____ [3]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

[illegible]

[illegible]

[illegible]

