UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Subsidiary Level and Advanced Level

**CHEMISTRY** **9701/01**

Paper 1 Multiple Choice

October/November 2004

**1 hour**

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C**, and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate answer sheet.

**Read the instructions on the answer sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.



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## Section A

For each question there are four possible answers, **A**, **B**, **C**, and **D**. Choose the **one** you consider to be correct.

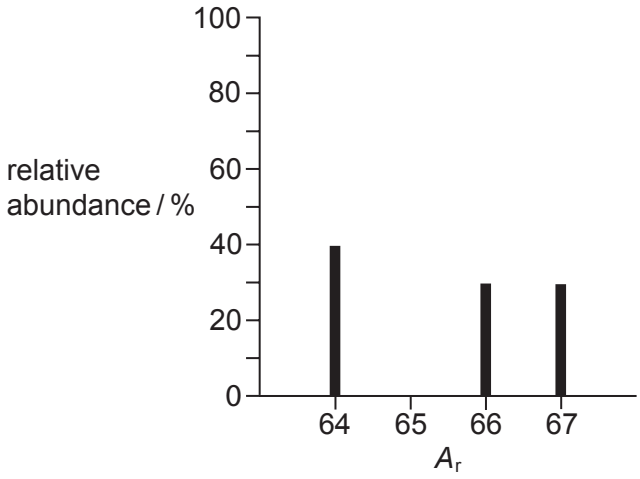
**1** Granular urea, $CON_2H_4$, can be used to remove $NO_2$ from the flue gases of power stations, converting it into harmless nitrogen.

$$2CON_2H_4 + x\,NO_2 \rightarrow 2CO_2 + y\,H_2O + z\,N_2$$

What are the values of *x*, *y* and *z* in a balanced equation?

| | *x* | *y* | *z* |
|---|---|---|---|
| **A** | 1½ | 2 | 1¼ |
| **B** | 2 | 4 | 3 |
| **C** | 3 | 4 | 3½ |
| **D** | 3 | 4 | 3 |

**2** The diagram shows the mass spectrum of a sample of zinc. Use the data to calculate the relative atomic mass of the sample.




**A** 65 **B** 65.25 **C** 65.5 **D** 65.66

**3** The foul smell that skunks spray is due to a number of thiols, one of which is methanethiol, $CH_3SH$, which burns as follows.

$$CH_3SH + 3O_2 \rightarrow CO_2 + SO_2 + 2H_2O$$

A sample of 10 $cm^3$ of methanethiol was exploded with 60 $cm^3$ of oxygen.

What would be the final volume of the resultant mixture of gases when cooled to room temperature?

**A** 20 $cm^3$ **B** 30 $cm^3$ **C** 50 $cm^3$ **D** 70 $cm^3$

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**4** *Use of the Data Booklet is relevant to this question.*

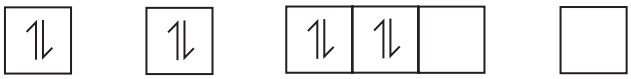
It is now thought that where an element exists as several isotopes, the stable ones usually contain a 'magic number' of neutrons. One of these magic numbers is 126.

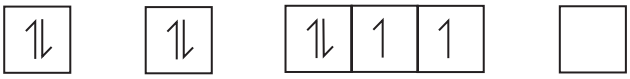
Which isotope is unstable?

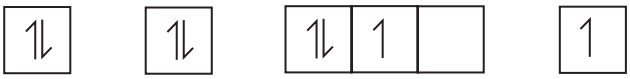
**A** $^{209}Bi$ **B** $^{208}Pb$ **C** $^{210}Po$ **D** $^{208}Tl$

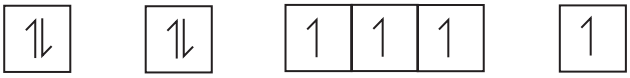
**5** An atom has eight electrons.

Which diagram shows the electronic configuration of this atom in its lowest energy state?

**A** 

**B** 

**C** 

**D** 

**6** The gecko, a small lizard, can climb up a smooth glass window. The gecko has millions of microscopic hairs on its toes and each hair has thousands of pads at its tip. The result is that the molecules in the pads are extremely close to the glass surface on which the gecko is climbing.

What is the attraction between the gecko's toe pads and the glass surface?

**A** co-ordinate bonds

**B** covalent bonds

**C** ionic bonds

**D** van der Waals' forces

**7** What are the bond angles in the $PH_3$ molecule likely to be?

**A** 90° **B** 104° **C** 109° **D** 120°

**8** *Use of the Data Booklet is relevant to this question.*

Which expression gives the pressure exerted by $1.6 \times 10^{-3}$ mol of $N_2$ in a container of volume 3.0 $dm^3$ at 273 °C?

**A** $\dfrac{1.6 \times 10^{-3} \times 8.31 \times 273}{3.0 \times 10^{-6}}$ Pa

**B** $\dfrac{1.6 \times 10^{-3} \times 8.31 \times (273 + 273)}{3.0 \times 10^{-6}}$ Pa

**C** $\dfrac{1.6 \times 10^{-3} \times 8.31 \times 273}{3.0 \times 10^{-3}}$ Pa

**D** $\dfrac{1.6 \times 10^{-3} \times 8.31 \times (273 + 273)}{3.0 \times 10^{-3}}$ Pa

**9** Which of these compounds, on complete combustion of one mole, will release the greatest amount of energy?

**A** $CH_3CH_2CH_2OH$

**B** $CH_3CH_2CH_3$

**C** $CH_3CH_2CO_2H$

**D** $CH_3COCH_3$

**10** At high temperatures, steam decomposes into its elements according to the following equation.

$$2H_2O(g) \rightleftharpoons 2H_2(g) + O_2(g)$$

In one experiment at 1 atm pressure, it was found that 20 % of the steam had been converted into hydrogen and oxygen.

What are the values of the equilibrium partial pressures, in atm, of the components of this equilibrium?

| | partial pressure of steam | partial pressure of hydrogen | partial pressure of oxygen |
|---|---|---|---|
| **A** | $\frac{0.80 \times 1}{1.0}$ | $\frac{0.10 \times 1}{1.0}$ | $\frac{0.10 \times 1}{1.0}$ |
| **B** | $\frac{0.80 \times 1}{1.0}$ | $\frac{0.133 \times 1}{1.0}$ | $\frac{0.067 \times 1}{1.0}$ |
| **C** | $\frac{0.80 \times 1}{1.0}$ | $\frac{0.20 \times 1}{1.0}$ | $\frac{0.10 \times 1}{1.0}$ |
| **D** | $\frac{0.80 \times 1}{1.1}$ | $\frac{0.20 \times 1}{1.1}$ | $\frac{0.10 \times 1}{1.1}$ |

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**11** Which statement concerning the equilibrium reaction below is true?

$$2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$$

**A** An increase in acid concentration will result in an increase in the concentration of $Cr_2O_7^{2-}(aq)$.

**B** A redox reaction is taking place.

**C** The addition of a catalyst will result in an increase in the concentration of $Cr_2O_7^{2-}(aq)$ .

**D** The equilibrium constant, $K_c$, has no units.

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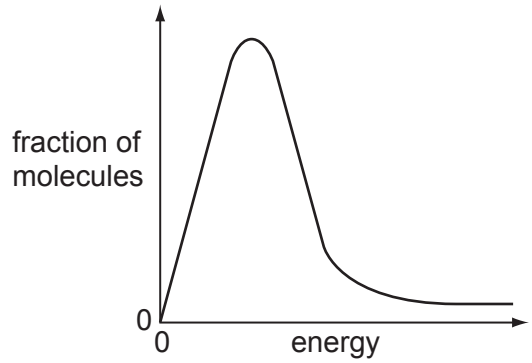
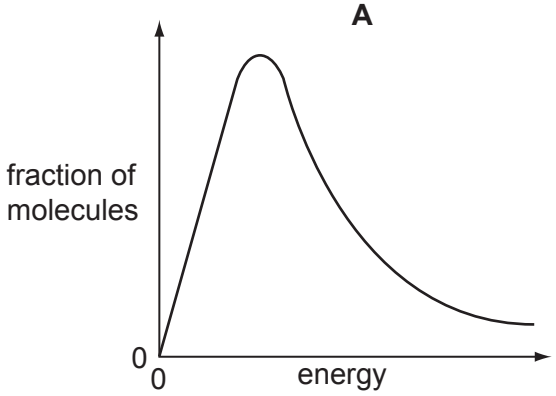
**12** The diagram shows the Boltzmann distribution for air at room temperature.



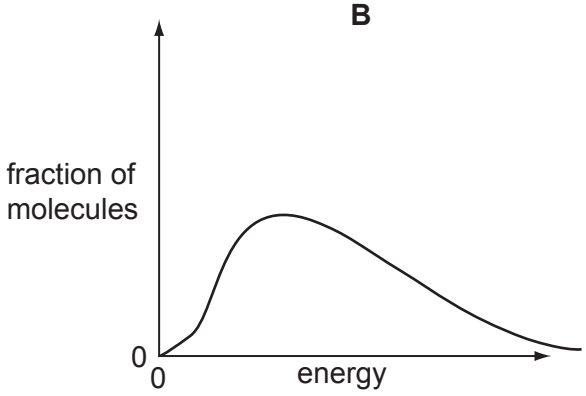

Air inside a car engine can reach a temperature of about 500 °C, enabling nitrogen to react with oxygen to form nitrogen oxides.

What would be the Boltzmann distribution for the air inside this car engine?

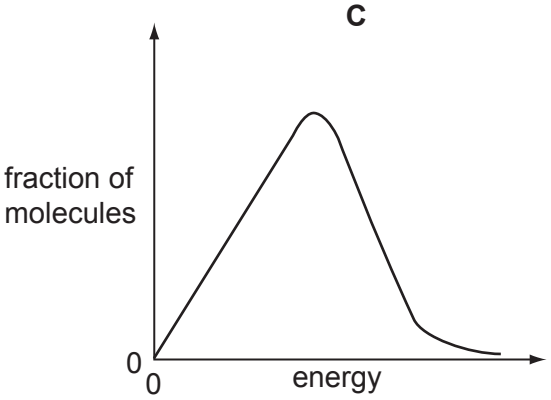
**A**



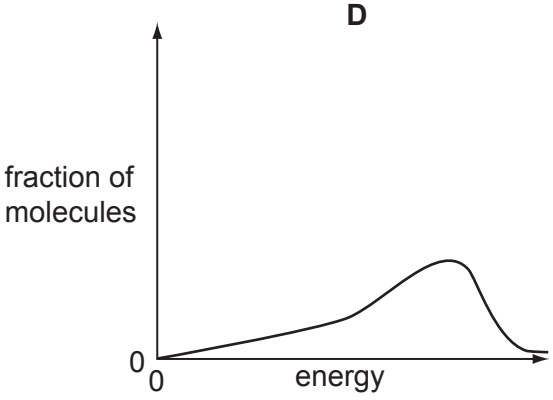

**B**




**C**




**D**

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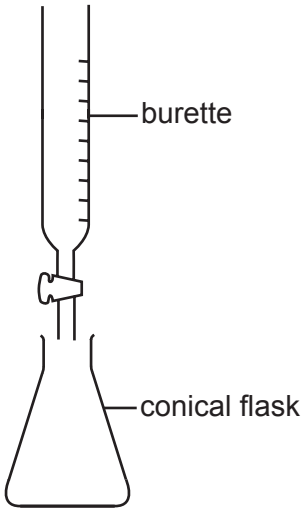
**13**




Which of these acid-base (neutralisation) reactions could be titrated using the apparatus shown above to give a sharp end-point?

**A** sulphuric acid and aluminium oxide

**B** sulphuric acid and magnesium hydroxide

**C** sulphuric acid and magnesium oxide

**D** sulphuric acid and sodium hydroxide

**14** The species Ar, $K^+$ and $Ca^{2+}$ are isoelectronic (have the same number of electrons).

In what order do their radii increase?

| | smallest ⟶ largest | | |
|---|---|---|---|
| **A** | Ar | $Ca^{2+}$ | $K^+$ |
| **B** | Ar | $K^+$ | $Ca^{2+}$ |
| **C** | $Ca^{2+}$ | $K^+$ | Ar |
| **D** | $K^+$ | Ar | $Ca^{2+}$ |

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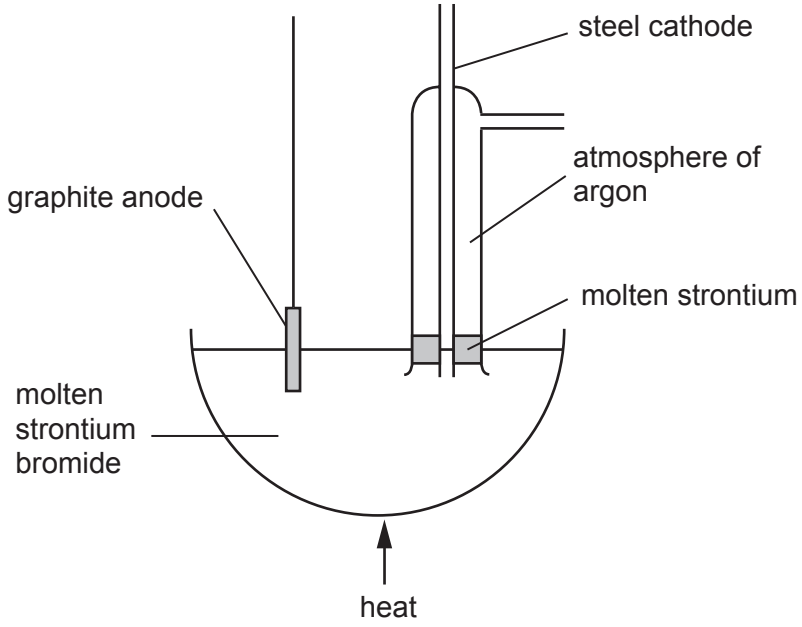
**15** Strontium metal can be obtained by the electrolysis of molten strontium bromide, $SrBr_2$, using the apparatus shown in the diagram.




Why is an atmosphere of argon used around the cathode?

**A** The argon keeps the strontium molten.

**B** The argon stops the molten strontium rising too high in the tube.

**C** A thin film of a compound of strontium and argon forms on the surface protecting the freshly formed metal.

**D** Without the argon strontium oxide would form in the air.

**16** A weedkiller can be prepared by heating a bleach solution.

$$\underset{\text{bleach}}{3NaClO} \xrightarrow{\text{heat}} \underset{\text{weedkiller}}{2NaCl + NaClO_3}$$

What are the oxidation states of chlorine in these three compounds?

| | | | |
|---|---|---|---|
| **A** | –1 | –1 | +5 |
| **B** | +1 | –1 | +5 |
| **C** | +1 | –1 | +7 |
| **D** | +2 | +1 | +7 |

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**17** The following report appeared in a newspaper.

> Drums of bromine broke open after a vehicle crash on the motorway. Traffic was diverted as purple gaseous bromine drifted over the road (it is denser than air), causing irritation to drivers' eyes. Firemen sprayed water over the scene of the accident, dissolving the bromine and washing it away.

What is **wrong** with the report?

**A** Bromine does not dissolve in water.

**B** Bromine does not vapourise readily.

**C** Bromine is less dense than air.

**D** Bromine is not purple.

**18** Which reaction of ammonia does **not** involve the non-bonding pair of electrons on the nitrogen atom?

**A** $NH_3(g) + CH_3I(g) \rightarrow CH_3NH_3^+I^-(s)$

**B** $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$

**C** $2NH_3(l) + 2Na(s) \rightarrow 2NaNH_2(s) + H_2(g)$

**D** $2NH_3(aq) + Ag^+(aq) \rightarrow [Ag(NH_3)_2]^+(aq)$

**19** Ammonium sulphate in nitrogenous fertilisers in the soil can be slowly oxidised by air producing sulphuric acid, nitric acid and water.

How many moles of oxygen are needed to oxidise completely one mole of ammonium sulphate?

**A** 1 **B** 2 **C** 3 **D** 4

**20** What can behave as an electrophilic reagent?

**A** $Br_2$

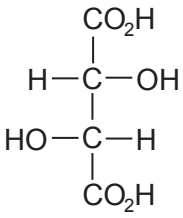
**B** Na

**C** $NH_3$

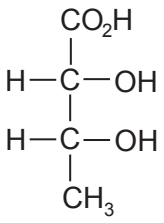
**D** $CN^-$

**21** Which molecule does not have a chiral centre?

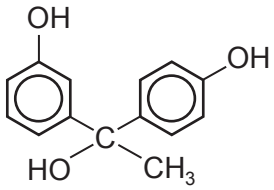
**A**



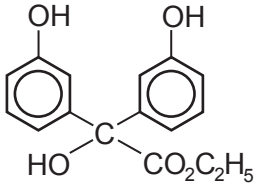
**B**



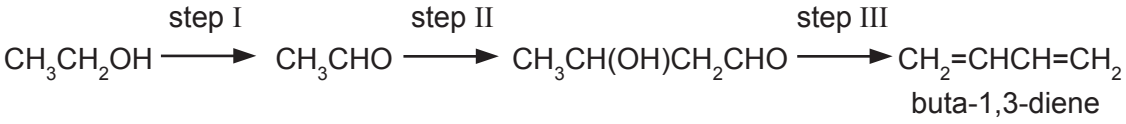
**C**



**D**



**22** Instead of obtaining buta-1,3-diene from fossil fuel sources, it is proposed to obtain it from ethanol, which can be obtained from non–food agricultural crops. The sequence of reactions is as follows.




Which term could be used to describe step I?

**A** condensation

**B** dehydration

**C** dehydrogenation

**D** hydrogenation

**23** How many different substitution products are possible, in principle, when a mixture of bromine and ethane is allowed to react?

**A** 3 **B** 5 **C** 7 **D** 9

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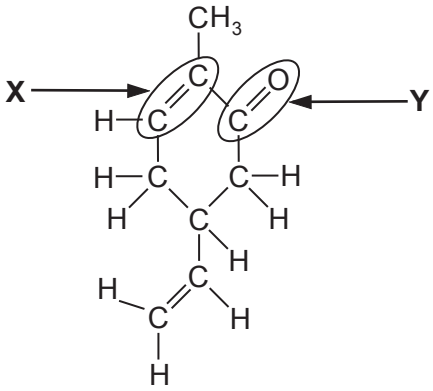
**24** This molecule is responsible for the flavour of spearmint chewing gum.




What is a true statement about the functional groups **X** or **Y**?

**A** **X** will undergo nucleophilic addition.

**B** **Y** will undergo nucleophilic addition.

**C** **X** will undergo electrophilic substitution.

**D** **Y** will undergo electrophilic substitution.

**25** Which reaction occurs with saturated hydrocarbons?

**A** catalytic hydrogenation

**B** ready decolourisation of aqueous bromine

**C** polymerisation

**D** thermal cracking

**26** The reaction of chlorine with methane is carried out in the presence of light.

What is the function of the light?

**A** to break the C – H bonds in methane

**B** to break up the chlorine molecules into atoms

**C** to break up the chlorine molecules into ions

**D** to heat up the mixture

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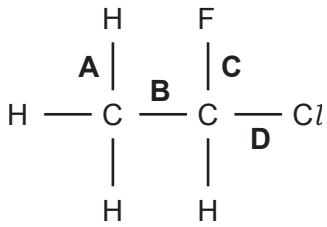
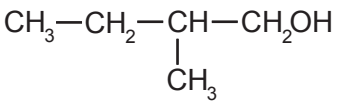
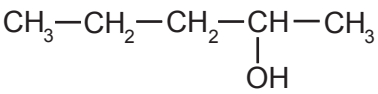
**27** *Use of the Data Booklet is relevant to this question.*

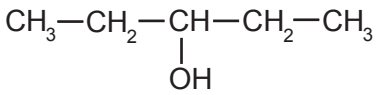
Which of the bonds in the structure below has the lowest bond energy?

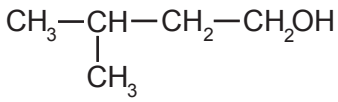



**28** Which isomer of $C_5H_{11}OH$ gives, on dehydration, the greatest number of different alkenes?

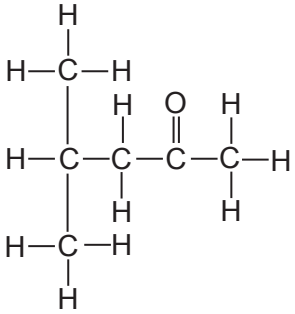
**A** 


**B** 


**C** 


**D** 


**29** The solvent methylisobutylketone, MIBK, can be made from propanone.



Which reagent could distinguish this compound from an aldehyde?

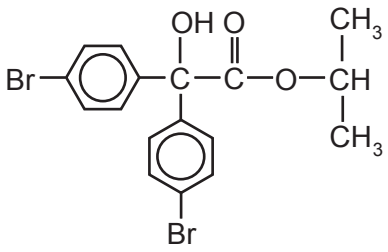
**A** $Br_2(aq)$

**B** 2,4-dinitrophenylhydrazine

**C** $NaBH_4$

**D** Tollens' reagent

**30** *Acarol* is sold as an insecticide for use on fruit and vegetables.




*Acarol*

The final stage of its manufacture is an esterification.

Which alcohol is used to form the ester?

**A** di(4-bromophenyl)methanol

**B** methanol

**C** propan-1-ol

**D** propan-2-ol

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**[Turn over**

## Section B

For each of the questions in this section, one or more of the three numbered statements **1** to **3** may be correct.

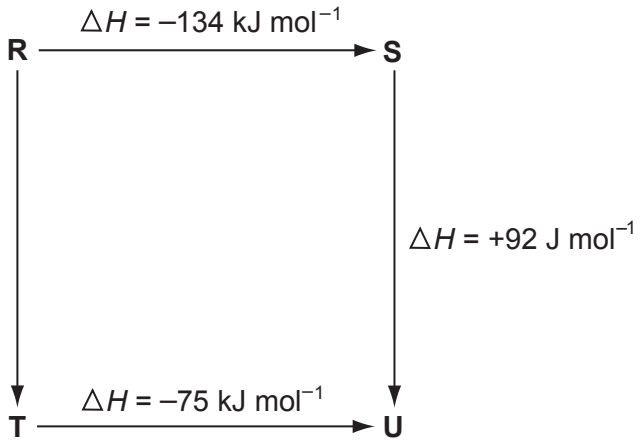
Decide whether each of the statements is or is not correct (you may find it helpful to put a tick against the statements that you consider to be correct).

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**31** The diagram illustrates the energy changes of a set of reactions.




Which of the following statements are correct?

**1** The enthalpy change for the transformation **U** ⟶ **R** is + 42 kJ $mol^{-1}$ .

**2** The enthalpy change for the transformation **T** ⟶ **S** is endothermic.

**3** The enthalpy change for the transformation **R** ⟶ **T** is – 33 kJ $mol^{-1}$ .

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**32** Ammonia is produced commercially by the Haber process in which nitrogen and hydrogen react as shown.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) \; ; \; \Delta H = -92\,kJ\,mol^{-1}$$

Which statements are true of the commercial process?

**1** A temperature of 1000 °C is used.

**2** A pressure of 100 - 200 atm is used.

**3** The yield of ammonia is less than 20 %.

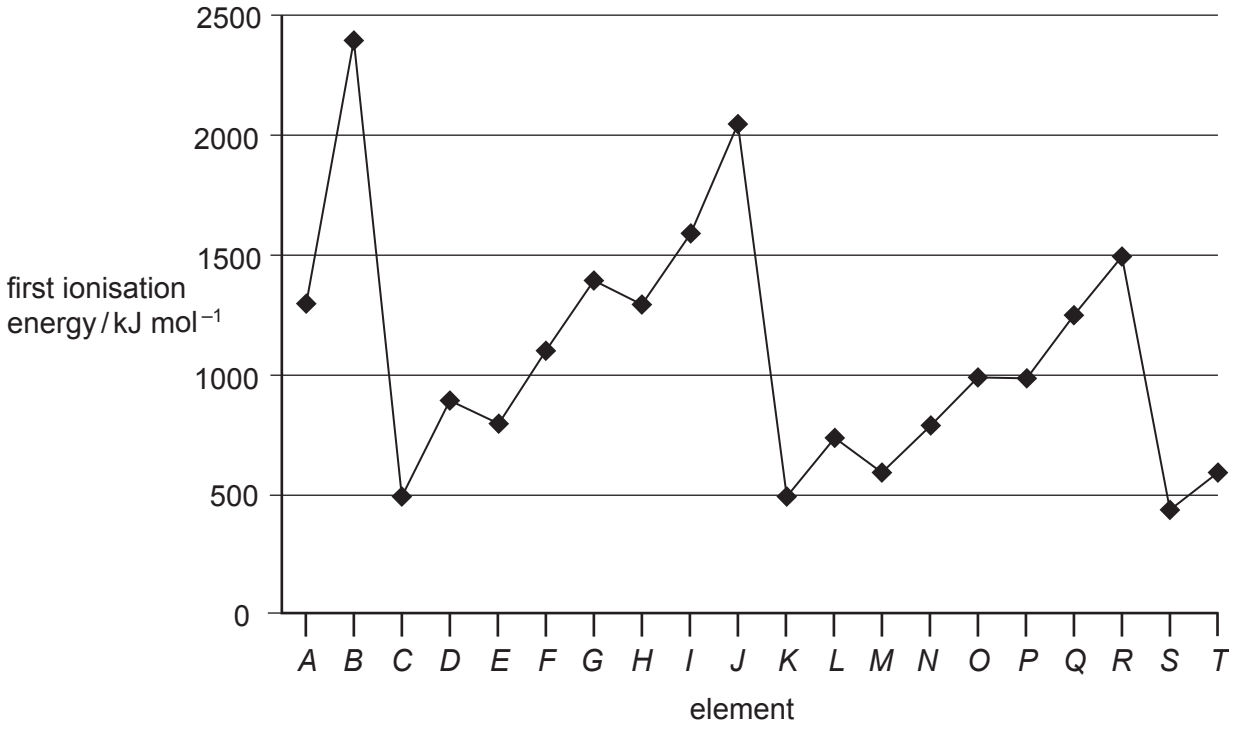
**33** What factors can affect the value of the activation energy of a reaction?

**1** the presence of a catalyst

**2** changes in temperature

**3** changes in concentration of the reactants

**34** The first ionisation energies of successive elements in the Periodic Table are represented in the graph.




Which of these statements about this graph are correct?

**1** Elements *B*, *J* and *R* are in Group 0 of the Periodic Table.

**2** Atoms of elements *D* and *L* contain 2 electrons in their outer shells.

**3** Atoms of elements *G* and *O* contain half-filled p orbitals.

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**35** Which reactions involving calcium and its compounds would produce **two** gaseous products?

**1** heating solid anhydrous calcium nitrate

**2** heating solid anhydrous calcium carbonate

**3** adding calcium metal to water

**36** Which properties in the sequence hydrogen chloride, hydrogen bromide and hydrogen iodide steadily increase?

**1** thermal stability

**2** bond length

**3** ease of oxidation

**37** Which compounds may result from mixing ethane and chlorine in the presence of sunlight?

**1** $CH_3CH_2Cl$

**2** $CH_3CH_2CH_2CH_3$

**3** $CH_3CHClCHClCH_3$

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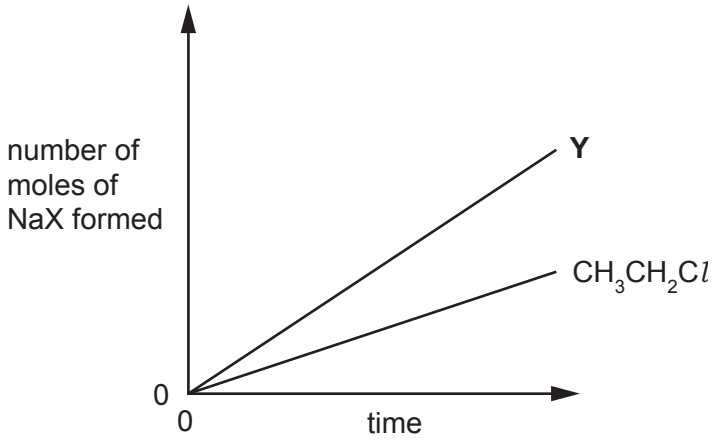
**38** When halogenoalkanes, RX, are hydrolysed with NaOH, the corresponding sodium halide, NaX, is produced.

$$RX + NaOH \rightarrow ROH + NaX$$

A student investigated the amount of NaX produced by hydrolysing $CH_3CH_2Cl$ and another halogenoalkane, **Y**. In a given time the amount of sodium halide formed was greater with **Y** than with $CH_3CH_2Cl$.



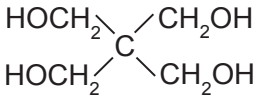

Which compound could be **Y**?

**1** $ClCH_2CH_2Cl$

**2** $CH_3CH_2Br$

**3** $CH_3CH_2I$

**39** Pentaerythritol is an intermediate in the manufacture of paint.




pentaerythritol

Which of the following statements about pentaerythritol are correct?

**1** It reacts with metallic sodium.

**2** It is dehydrated by concentrated sulphuric acid to an alkene.

**3** Its empirical formula is $CH_3O$.

The responses **A** to **D** should be selected on the basis of

| A | B | C | D |
|---|---|---|---|
| **1, 2** and **3** are correct | **1** and **2** only are correct | **2** and **3** only are correct | **1** only is correct |

No other combination of statements is used as a correct response.

**40** Lactic acid builds up in muscles when oxygen is in short supply. It can cause muscular pain. Part of the reaction sequence is shown.

$$CH_2OHCH(OH)CHO \rightarrow CH_3COCO_2H \rightarrow CH_3CH(OH)CO_2H$$

glyceraldehyde pyruvic acid lactic acid

Which statements about the reaction sequence are correct?

**1** An aldehyde is oxidised to a carboxylic acid.

**2** A ketone is reduced to a secondary alcohol.

**3** A secondary alcohol is oxidised to a ketone.

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