



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

**CHEMISTRY**

**9701/01**

Paper 1 Multiple Choice

**May/June 2007**

**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.

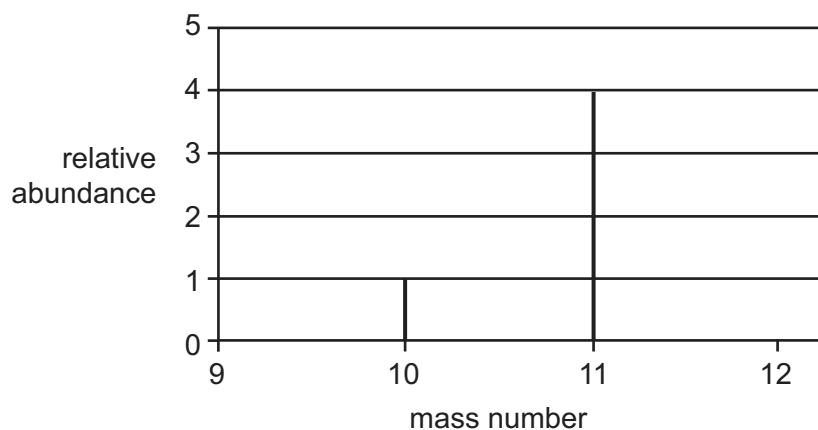
This document consists of **14** printed pages and **2** blank pages.



## Section A

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

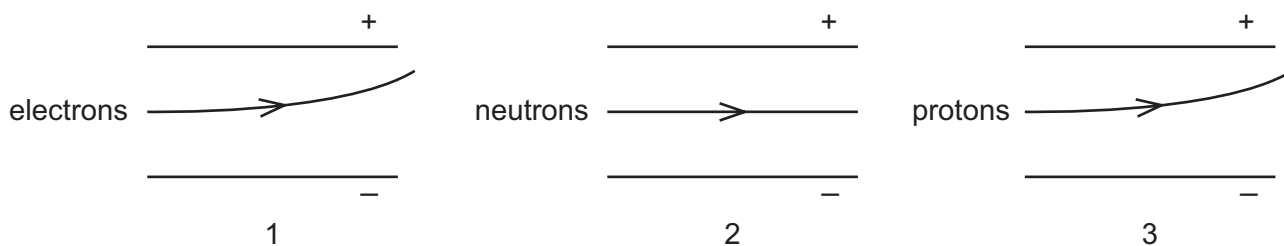
- 1 The isotopic composition of an element is indicated below.



What is the relative atomic mass of the element?

- A** 10.2                      **B** 10.5                      **C** 10.8                      **D** 11.0
- 2 *Use of the Data Booklet is relevant to this question.*
- Oxides of nitrogen are pollutant gases which are emitted from car exhausts.
- In urban traffic, when a car travels one kilometre, it releases 0.23 g of an oxide of nitrogen  $N_xO_y$ , which occupies  $120 \text{ cm}^3$ .
- What are the values of  $x$  and  $y$ ?  
(Assume 1 mol of gas molecules occupies  $24.0 \text{ dm}^3$ .)
- A**  $x = 1, y = 1$   
**B**  $x = 1, y = 2$   
**C**  $x = 2, y = 1$   
**D**  $x = 2, y = 4$
- 3 John Dalton's atomic theory, published in 1808, contained four predictions about atoms.
- Which of his predictions is still considered to be correct?
- A** Atoms are very small in size.  
**B** No atom can be split into simpler parts.  
**C** All the atoms of a particular element have the same mass.  
**D** All the atoms of one element are different in mass from all the atoms of other elements.

- 4 The diagrams show the possible paths of subatomic particles moving in an electric field in a vacuum.



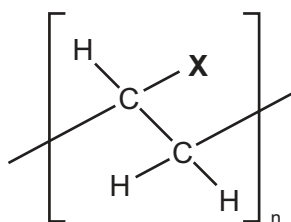
Which diagrams are correct?

- A** 1 and 2 only  
**B** 1 and 3 only  
**C** 2 and 3 only  
**D** 1, 2 and 3
- 5 The  $\text{CN}^-$  ion is widely used in the synthesis of organic compounds.

What is the pattern of electron pairs in this ion?

|          | bonding pairs of electrons | lone pairs on carbon atom | lone pairs on nitrogen atom |
|----------|----------------------------|---------------------------|-----------------------------|
| <b>A</b> | 2                          | 1                         | 1                           |
| <b>B</b> | 2                          | 2                         | 1                           |
| <b>C</b> | 3                          | 1                         | 1                           |
| <b>D</b> | 3                          | 1                         | 2                           |

- 6 Plastic bottles for 'fizzy drinks' are made from a polymer with the following structure.



The ability of the polymer to prevent escape of carbon dioxide through the wall of the bottle depends on the ability of the group **X** to form hydrogen bonds with the carbon dioxide in the drink.

Which group **X** best prevents loss of carbon dioxide?

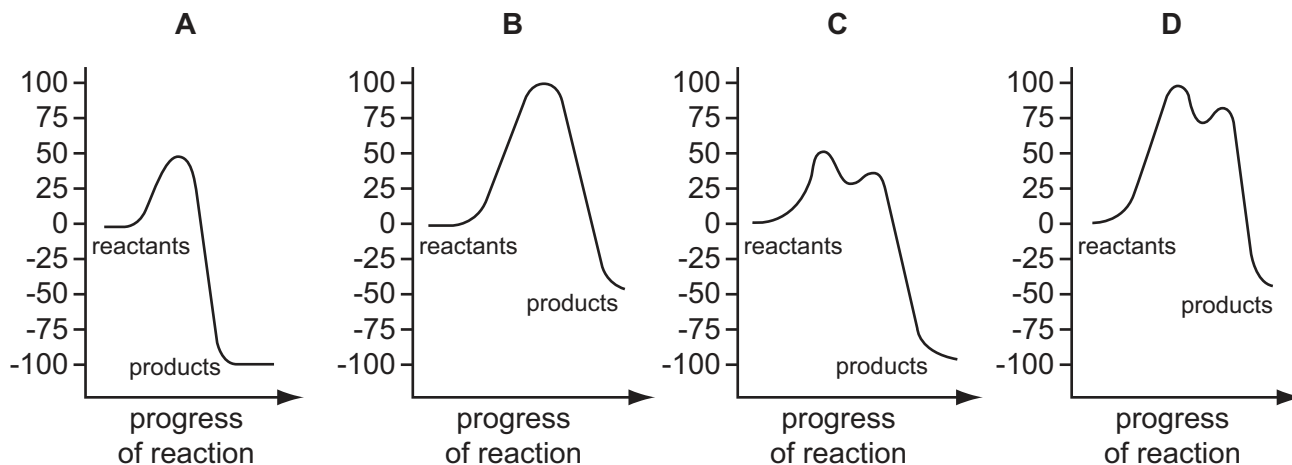
- A** Cl                      **B** CN                      **C**  $\text{CO}_2\text{CH}_3$                       **D** OH

- 7 An exothermic chemical reaction proceeds by two stages.

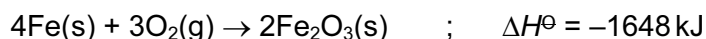


The activation energy of stage 1 is  $50 \text{ kJ mol}^{-1}$ . The overall enthalpy change of reaction is  $-100 \text{ kJ mol}^{-1}$ .

Which diagram represents the reaction pathway for this reaction?



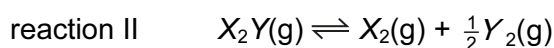
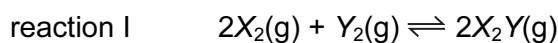
- 8 Skiers trapped by snowstorms use heat packs to keep warm. The heat may be generated by the reaction below.



What is the standard enthalpy change of formation of iron(III) oxide?

- A  $0 \text{ kJ mol}^{-1}$   
 B  $-824 \text{ kJ mol}^{-1}$   
 C  $-1648 \text{ kJ mol}^{-1}$   
 D  $-3296 \text{ kJ mol}^{-1}$

- 9 Two equilibria are shown below.

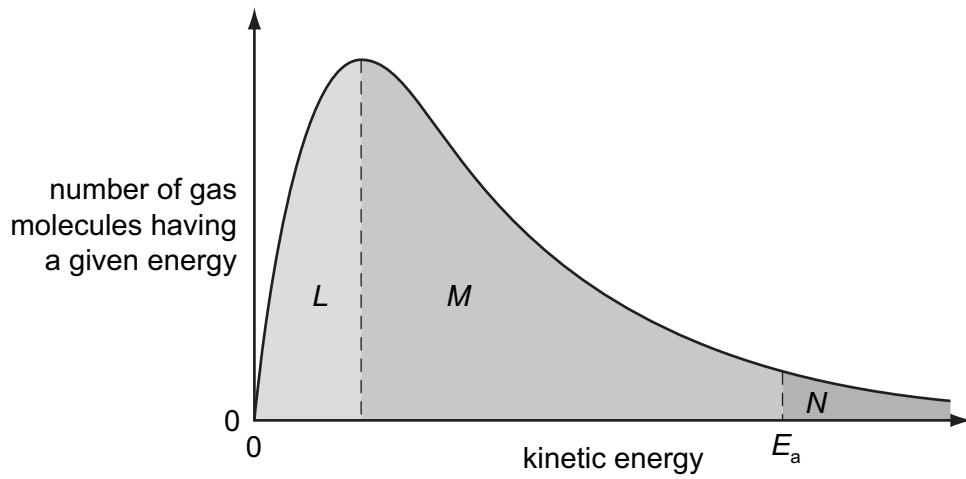


The numerical value of  $K_c$  for reaction I is 2.

Under the same conditions, what is the numerical value of  $K_c$  for reaction II?

- A  $\frac{1}{\sqrt{2}}$       B  $\frac{1}{2}$       C  $\frac{1}{4}$       D  $-2$

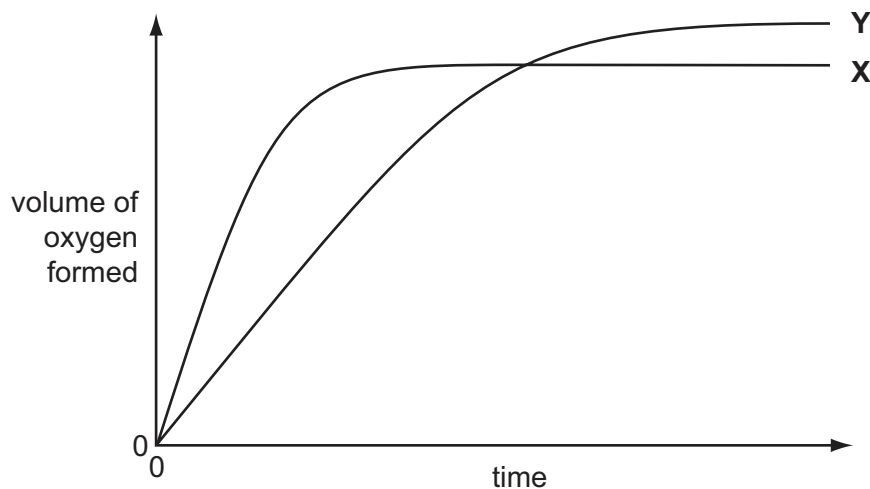
- 10 The Boltzmann distribution shows the number of molecules having a particular kinetic energy at constant temperature.



If the temperature is decreased by  $10^{\circ}\text{C}$ , what happens to the size of the areas labelled  $L$ ,  $M$  and  $N$ ?

|          | $L$       | $M$       | $N$       |
|----------|-----------|-----------|-----------|
| <b>A</b> | decreases | decreases | decreases |
| <b>B</b> | decreases | increases | decreases |
| <b>C</b> | increases | decreases | decreases |
| <b>D</b> | increases | decreases | increases |

- 11 In the diagram, curve **X** was obtained by observing the decomposition of  $100\text{ cm}^3$  of  $1.0\text{ mol dm}^{-3}$  hydrogen peroxide, catalysed by manganese(IV) oxide.



Which alteration to the original experimental conditions would produce curve **Y**?

- A** adding water  
**B** adding some  $0.1\text{ mol dm}^{-3}$  hydrogen peroxide  
**C** using less manganese(IV) oxide  
**D** lowering the temperature
- 12 Which chlorine compound has bonding that can be described as ionic with some covalent character?
- A**  $\text{NaCl}$       **B**  $\text{MgCl}_2$       **C**  $\text{AlCl}_3$       **D**  $\text{SiCl}_4$
- 13  $\text{AlCl}_3$  reacts with  $\text{LiAlH}_4$  and  $(\text{CH}_3)_3\text{N}$  to give  $(\text{CH}_3)_3\text{NAlH}_3$ .

Which statement about  $(\text{CH}_3)_3\text{NAlH}_3$  is correct?

- A** It contains hydrogen bonding.  
**B** It is dimeric.  
**C** The  $\text{Al}$  atom has an incomplete octet of electrons.  
**D** The bonds around the  $\text{Al}$  atom are tetrahedrally arranged.

- 14 Slaked lime,  $\text{Ca(OH)}_2$ , may be made from limestone,  $\text{CaCO}_3$ .

On heating in a lime kiln at  $1000^\circ\text{C}$ , limestone decomposes as follows.



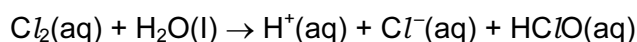
Water is then reacted with calcium oxide,  $\text{CaO}$ , as follows.



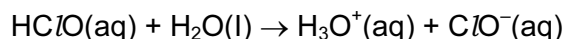
What are the enthalpy changes of these reactions?

|          | reaction 1  | reaction 2  |
|----------|-------------|-------------|
| <b>A</b> | endothermic | endothermic |
| <b>B</b> | endothermic | exothermic  |
| <b>C</b> | exothermic  | endothermic |
| <b>D</b> | exothermic  | exothermic  |

- 15 In the treatment of domestic water supplies, chlorine is added to the water to form chloric(I) acid,  $\text{HClO}$ .



This reacts further to give the chlorate(I) ion.



Both  $\text{HClO}$  and  $\text{ClO}^-$  kill bacteria by oxidation.

What is the change in oxidation number of chlorine in forming the chlorate(I) ion from the aqueous chlorine?

- A** -1                      **B** 0                      **C** +1                      **D** +2

- 16 The standard enthalpy changes of formation of  $\text{HCl}$  and  $\text{HI}$  are  $-92 \text{ kJ mol}^{-1}$  and  $+26 \text{ kJ mol}^{-1}$  respectively.

Which statement is **most** important in explaining this difference?

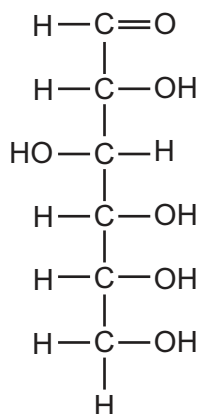
- A** Chlorine is more electronegative than iodine.  
**B** The activation energy for the  $\text{H}_2/\text{Cl}_2$  reaction is much less than that for the  $\text{H}_2/\text{I}_2$  reaction.  
**C** The bond energy of  $\text{HI}$  is smaller than the bond energy of  $\text{HCl}$ .  
**D** The bond energy of  $\text{I}_2$  is smaller than the bond energy of  $\text{Cl}_2$ .

- 17 Methyl mercaptan,  $\text{CH}_3\text{SH}$ , is one of the substances responsible for bad breath and is often used to impart a smell to natural gas in a pipeline.

What will be formed when  $\text{CH}_3\text{SH}$  is burned in an excess of air?

- A  $\text{CO}$   $\text{CO}_2$   $\text{H}_2\text{S}$   
 B  $\text{CO}$   $\text{H}_2\text{O}$   $\text{SO}_3$   
 C  $\text{CO}_2$   $\text{H}_2\text{O}$   $\text{SO}_2$   
 D  $\text{CO}_2$   $\text{H}_2\text{O}$   $\text{SO}_3$
- 18 A solid nitrate fertiliser reacts with an alkali to produce a gas which turns damp pH paper blue.
- What is the empirical formula of this fertiliser?
- A  $\text{NO}_3$                       B  $\text{NHO}_3$                       C  $\text{NH}_2\text{O}$                       D  $\text{N}_2\text{H}_4\text{O}_3$
- 19 Glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$ , is a product of photosynthesis.

It has the following structure.



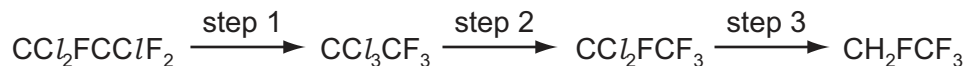
How many *chiral* centres does the molecule have?

- A 1                                  B 2                                  C 4                                  D 6



- 20 Under the Montreal Protocol, the manufacture of chlorofluorocarbons has been phased out, and they are being replaced by fluorocarbons.

One chlorofluorocarbon which was widely used as a solvent is  $\text{CCl}_2\text{FCClF}_2$ . Large stocks of it remain. One process to use up these stocks is to convert it into the fluorocarbon  $\text{CH}_2\text{FCF}_3$  by the following route.



What type of reaction is step 2?

- A electrophilic substitution
  - B free radical reduction
  - C isomerisation
  - D nucleophilic substitution
- 21 Which reagent could be used to convert  $\text{CH}_3\text{CO}_2\text{CH}_3$  into  $\text{ClCH}_2\text{CO}_2\text{CH}_3$ ?

- A concentrated hydrochloric acid at  $100^\circ\text{C}$
- B phosphorus pentachloride at room temperature
- C sulphur dichloride oxide (thionyl chloride,  $\text{SOCl}_2$ ) at  $50^\circ\text{C}$
- D chlorine in bright sunlight at  $100^\circ\text{C}$

- 22 In which reaction is a carbocation (carbonium ion) an intermediate?

- A  $\text{CH}_2=\text{CH}_2 + \text{Br}_2 \longrightarrow \text{CH}_2\text{BrCH}_2\text{Br}$
- B  $\text{CH}_3\text{CH}_2\text{Br} + \text{NaOH} \longrightarrow \text{CH}_3\text{CH}_2\text{OH} + \text{NaBr}$
- C  $\text{CH}_3\text{CH}_3 + \text{Cl}_2 \longrightarrow \text{CH}_3\text{CH}_2\text{Cl} + \text{HCl}$
- D  $\text{CH}_3\text{CHO} + \text{HCN} \xrightarrow{\text{CN}^-} \text{CH}_3\text{CH}(\text{OH})\text{CN}$

- 23 The compound 1,2-dichloroethene,  $\text{C}_2\text{H}_2\text{Cl}_2$ , has been used as an industrial solvent for a number of compounds including fats, camphor and caffeine.

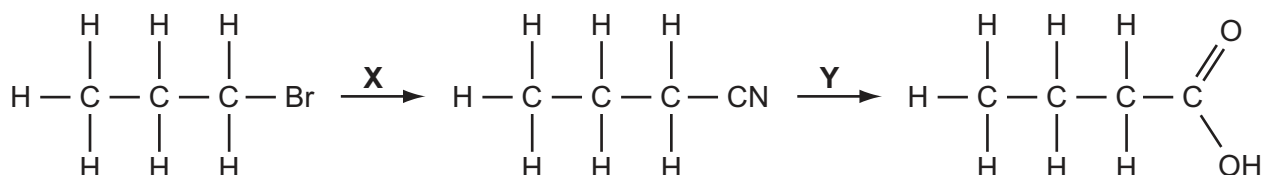
Which statement about this compound is **incorrect**?

- A The compound can be catalytically hydrogenated.
- B The compound is a planar molecule.
- C The compound shows *cis-trans* isomerism.
- D The compound shows optical isomerism.

24 Which term describes the action of NaOH(aq) on a bromoalkane?

- A acid-base reaction
- B electrophilic substitution
- C elimination of HBr
- D nucleophilic substitution

25 X and Y are the reagents required to convert 1-bromopropane into butanoic acid.



What are the correct identities of X and Y?

|   | X                                       | Y        |
|---|---|----------|
| A | NH <sub>3</sub>                         | HCl(aq)  |
| B | KCN in C <sub>2</sub> H <sub>5</sub> OH | NaOH(aq) |
| C | KCN in C <sub>2</sub> H <sub>5</sub> OH | HCl(aq)  |
| D | HCN                                     | NaOH(aq) |

26 An alcohol with molecular formula C<sub>n</sub>H<sub>2n+1</sub>OH has a chiral carbon atom but does not react with MnO<sub>4</sub><sup>-</sup> / H<sup>+</sup>.

What is the least number of carbon atoms such an alcohol could possess?

- A 5                      B 6                      C 7                      D 8

27 Which reagent gives the same visible result with propanal and with propan-2-ol?

- A 2,4-dinitrophenylhydrazine reagent
- B acidified potassium dichromate(VI)
- C sodium
- D Tollens' reagent

28 Compound **X** will decolourise a warm acidified solution of manganate(VII) ions and forms orange crystals on reaction with 2,4-dinitrophenylhydrazine.

What is **X**?

- A  $\text{CH}_3\text{CH}=\text{CHCH}_2\text{OH}$
- B  $\text{CH}_3\text{COCH}_2\text{CH}_3$
- C  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
- D  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CO}_2\text{H}$

29 Which compound would undergo nucleophilic addition?

- A ethene,  $\text{C}_2\text{H}_4$
- B bromoethane,  $\text{C}_2\text{H}_5\text{Br}$
- C ethanal,  $\text{CH}_3\text{CHO}$
- D ethane,  $\text{C}_2\text{H}_6$

30 Which formula represents the organic compound formed by the reaction of propanoic acid with methanol in the presence of concentrated sulphuric acid as a catalyst?

- A  $\text{CH}_3\text{CH}_2\text{COCH}_3$
- B  $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_3$
- C  $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$
- D  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}_3$

## 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

| <b>A</b>               | <b>B</b>                 | <b>C</b>                 | <b>D</b>          |
|------------------------|--------------------------|--------------------------|-------------------|
| 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** *Use of the Data Booklet is relevant to this question.*

The technetium-99 isotope ( $^{99}\text{Tc}$ ) is radioactive and has been found in lobsters and seaweed adjacent to nuclear fuel reprocessing plants.

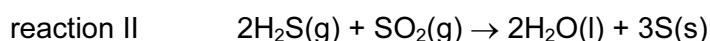
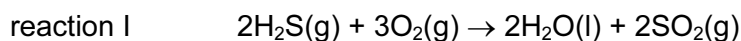
Which statements are correct about an atom of  $^{99}\text{Tc}$ ?

- 1 It has 13 more neutrons than protons.
- 2 It has 43 protons.
- 3 It has 99 nucleons.

**32** Which of the following solids contain more than one type of chemical bond?

- 1 brass (an alloy of copper and zinc)
- 2 graphite
- 3 ice

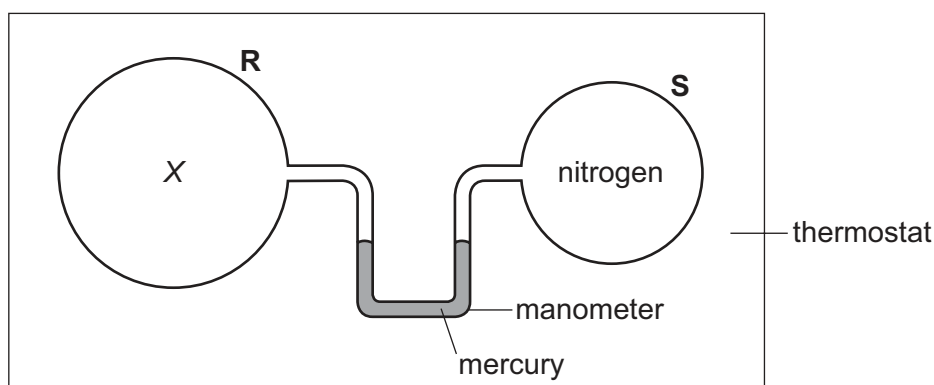
**33** Many crude oils contain sulphur as  $\text{H}_2\text{S}$ . During refining, by the Claus process, the  $\text{H}_2\text{S}$  is converted into solid sulphur, which is then removed.



Which statements about the Claus process are correct?

- 1  $\text{H}_2\text{S}$  is oxidised in reaction I.
- 2  $\text{SO}_2$  oxidises  $\text{H}_2\text{S}$  in reaction II.
- 3  $\text{SO}_2$  behaves as a catalyst.

- 34 Two bulbs **R** and **S**, connected by a mercury manometer, are held in a thermostat, as shown. The volume of **R** is twice that of **S**. **R** contains gas, **X**, at the same pressure as the nitrogen in **S**.



When the temperature is increased, which gases in bulb **R** would cause the mercury level in the right-hand limb of the manometer to rise?

- 1 an equilibrium mixture  $\text{N}_2\text{F}_4(\text{g}) \rightleftharpoons 2\text{NF}_2(\text{g})$ ;  $\Delta H$  positive
  - 2 an equilibrium mixture  $\text{CH}_3\text{NC}(\text{g}) \rightleftharpoons \text{CH}_3\text{CN}(\text{g})$ ;  $\Delta H$  negative
  - 3 nitrogen
- 35 Which statements concerning the third period elements (sodium to argon) and their compounds are correct?
- 1 The elements become more electronegative from sodium to chlorine.
  - 2 Aluminium oxide is the only oxide which is insoluble in water.
  - 3 The maximum oxidation state is shown by silicon.
- 36 *Use of the Data Booklet is relevant to this question.*
- The element astatine lies below iodine in Group VII of the Periodic Table.
- What will be the properties of astatine?
- 1 It forms diatomic molecules which dissociate more readily than chlorine molecules.
  - 2 It reacts explosively with hydrogen.
  - 3 It is a good reducing agent.
- 37 Nitrogen and oxygen react in a hot car engine to form nitrogen monoxide which is a serious pollutant in our cities and in the countryside. However, nitrogen and oxygen do not react at room temperature.

Which statements help to explain why nitrogen and oxygen do not react at room temperature?

- 1 The reaction is endothermic.
- 2 A high activation energy is required.
- 3 Nitrogen has a high bond energy.

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

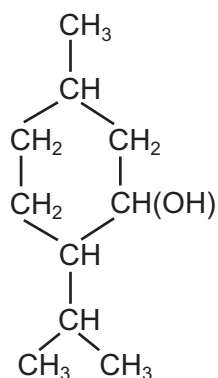
| <b>A</b>               | <b>B</b>                 | <b>C</b>                 | <b>D</b>          |
|------------------------|--------------------------|--------------------------|-------------------|
| 1, 2 and 3 are correct | 1 and 2 only are correct | 2 and 3 only are correct | 1 only is correct |

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

**38** What types of reaction are undergone by 2-bromopropane?

- 1 elimination
- 2 free radical substitution
- 3 nucleophilic substitution

**39** Menthol, from oil of mint, is used in soaps and perfumes.



menthol

Which statements about menthol are correct?

- 1 There is a total of two chiral centres present in the menthol molecule.
  - 2 On reaction with concentrated sulphuric acid, menthol produces a mixture of two alkenes.
  - 3 A solution of acidified potassium dichromate(VI), on warming with menthol, changes colour from orange to green.
- 40** Fats and grease that build up on pans used in cooking are esters. Pans which are dirty from fats or grease may be cleaned by heating them with a reagent that will react with the ester group.

What may be used to clean such pans by this reaction?

- 1 vinegar - aqueous ethanoic acid,  $\text{CH}_3\text{CO}_2\text{H}$
- 2 alcohol - ethanol,  $\text{C}_2\text{H}_5\text{OH}$
- 3 baking powder - sodium hydrogencarbonate,  $\text{NaHCO}_3$



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