

Cambridge  
International  
AS & A Level

**Cambridge International Examinations**  
Cambridge International Advanced Subsidiary and Advanced Level

**CHEMISTRY**

**9701/12**

Paper 1 Multiple Choice

**May/June 2017**

**1 hour**

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

**MODIFIED LANGUAGE**

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.

Do not use staples, paper clips, 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.

DO **NOT** WRITE IN ANY BARCODES.

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.

Electronic calculators may be used.

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.

Use of the Data Booklet may be appropriate for some questions.

1 In which species are the numbers of protons, neutrons and electrons **all** different?

- A**  ${}^{19}_9\text{F}^-$       **B**  ${}^{23}_{11}\text{Na}^+$       **C**  ${}^{31}_{15}\text{P}$       **D**  ${}^{32}_{16}\text{S}^{2-}$

2 Which would contain  $9.03 \times 10^{23}$  oxygen atoms?

- A** 0.25 mol aluminium oxide  
**B** 0.75 mol sulfur dioxide  
**C** 1.5 mol sulfur trioxide  
**D** 3.0 mol water

3 In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate. Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.

What is the equation for this reaction?

- A**  $2\text{Al} + \text{Ba}(\text{NO}_3)_2 \rightarrow \text{Al}_2\text{O}_3 + \text{BaO} + 2\text{NO}$   
**B**  $4\text{Al} + 4\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{Al}_2\text{O}_3 + 4\text{Ba}(\text{NO}_2)_2 + \text{O}_2$   
**C**  $10\text{Al} + 3\text{Ba}(\text{NO}_3)_2 \rightarrow 5\text{Al}_2\text{O}_3 + 3\text{BaO} + 3\text{N}_2$   
**D**  $10\text{Al} + 18\text{Ba}(\text{NO}_3)_2 \rightarrow 10\text{Al}(\text{NO}_3)_3 + 18\text{BaO} + 3\text{N}_2$

4 Which organic compound has the highest boiling point?

- A**  $\text{C}(\text{CH}_3)_4$   
**B**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$   
**C**  $\text{CH}_3\text{COCH}_2\text{CH}_3$   
**D**  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$

5 At a temperature of 2500 K and a pressure of  $1.00 \times 10^{-4}$  Pa a sample of 0.321 g of sulfur vapour has a volume of  $2.08 \times 10^6 \text{ m}^3$ .

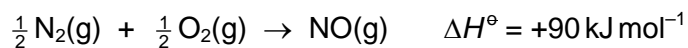
What is the molecular formula of sulfur under these conditions?

- A** S      **B**  $\text{S}_2$       **C**  $\text{S}_4$       **D**  $\text{S}_8$

6 Which reaction involves a decrease in the bond angle at a carbon atom?

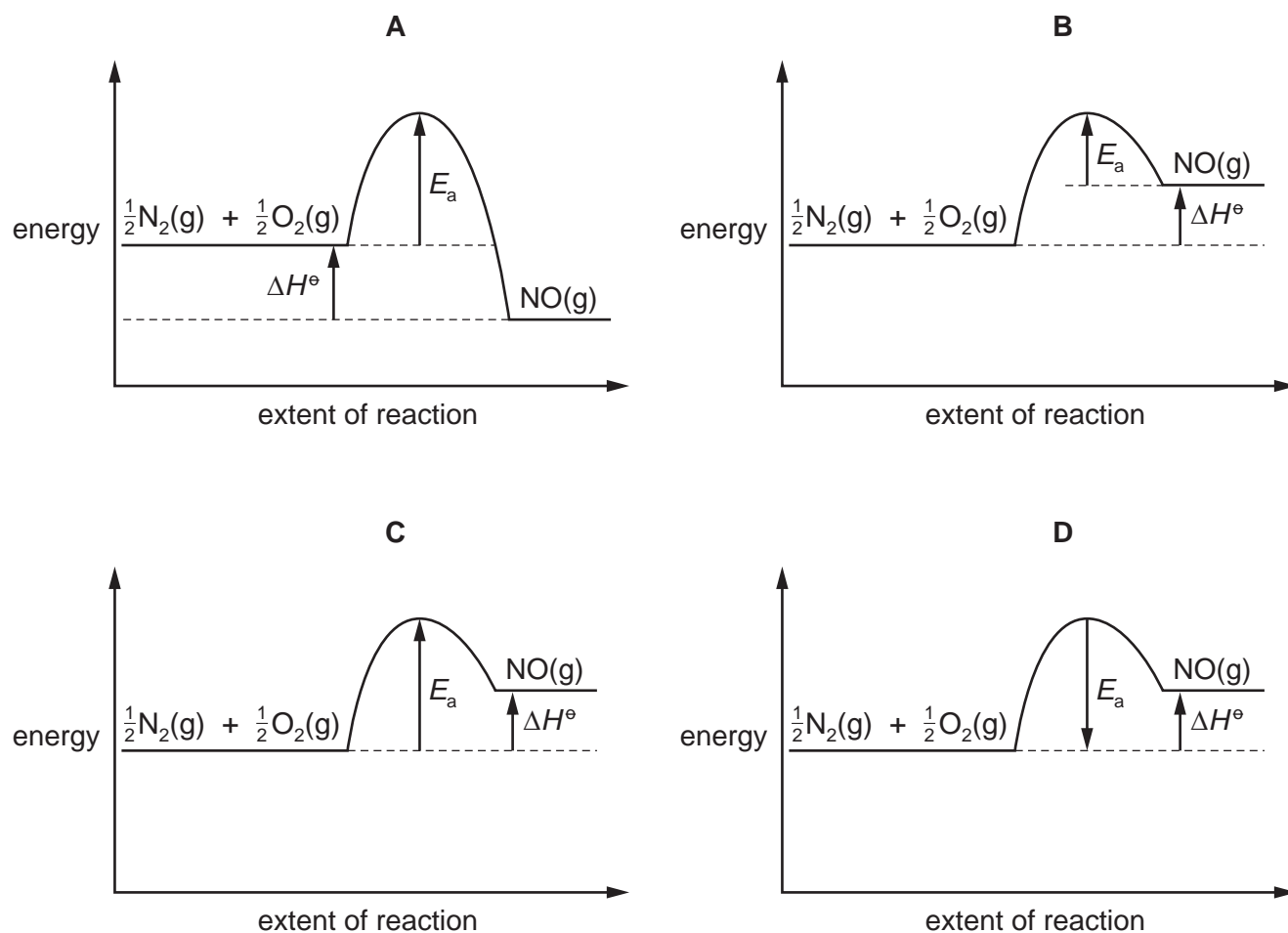
- A bromoethane refluxed with ethanolic sodium hydroxide
- B complete combustion of methane in air
- C ethanol heated with conc.  $\text{H}_2\text{SO}_4$
- D polymerisation of ethene

7 In the high temperatures of car engines, nitrogen reacts with oxygen to give nitrogen monoxide.

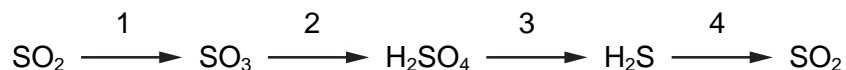


This reaction has activation energy  $E_a$ .

Which reaction pathway diagram could correctly represent this reaction?



- 8 A reaction sequence is shown.

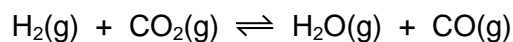


In each stage of this sequence the sulfur is oxidised, reduced or neither oxidised nor reduced.

Which row is correct?

	1	2	3	4
<b>A</b>	neither	oxidised	reduced	reduced
<b>B</b>	oxidised	neither	reduced	reduced
<b>C</b>	oxidised	neither	reduced	oxidised
<b>D</b>	oxidised	oxidised	reduced	oxidised

- 9 Hydrogen and carbon dioxide gases are mixed at 800 K. A reversible reaction takes place.

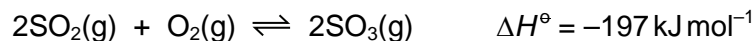


At equilibrium, the partial pressures of  $\text{H}_2$  and  $\text{CO}_2$  are both 10.0 kPa.  $K_p$  is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

- A** 5.37 kPa      **B** 18.6 kPa      **C** 28.8 kPa      **D** 347 kPa

- 10 A reaction involved in the Contact process is shown.

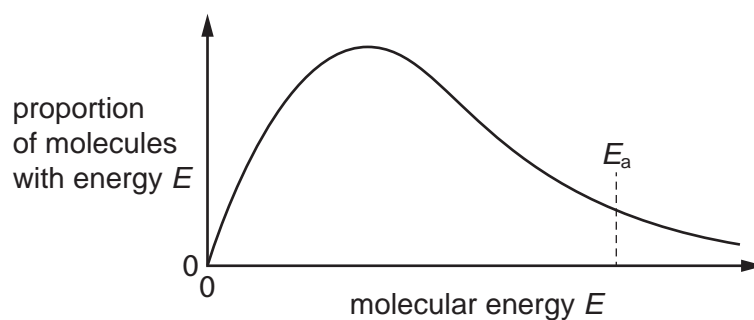


The reaction is investigated at 200 kPa and 700 K and the value of the equilibrium constant,  $K_p$ , is found to be Y. The reaction is then investigated at 1000 kPa and 700 K and the value of  $K_p$  is found to be Z.

Which statement comparing Y and Z is correct?

- A** Y and Z are the same.  
**B** Y is greater than Z.  
**C** Z is 2.2 times greater than Y.  
**D** Z is 5.0 times greater than Y.

- 11 The Boltzmann distribution for the hydrogenation of an alkene at a particular temperature in the absence of a catalyst is shown.



Which row correctly describes the effects of adding nickel to the reaction vessel?

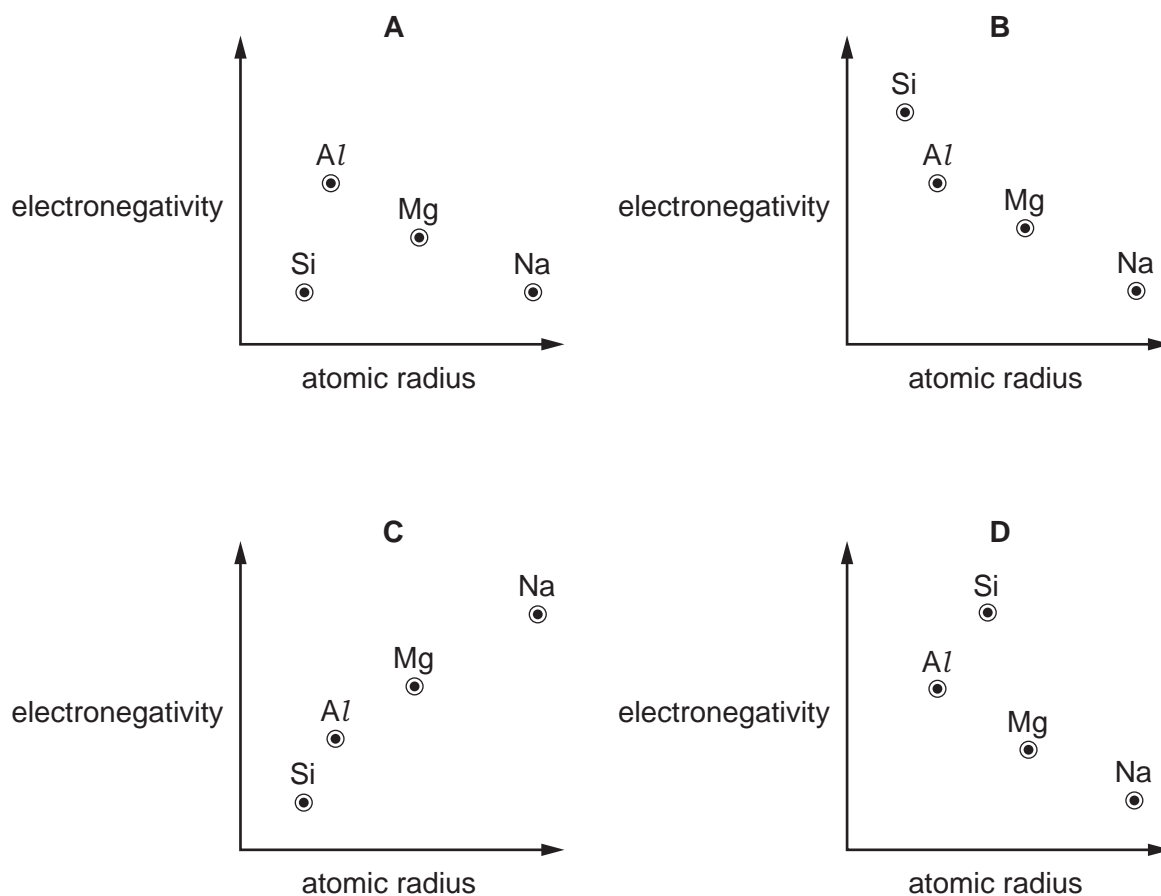
	the shape of the Boltzmann distribution	activation energy, $E_a$
<b>A</b>	changes	decreases
<b>B</b>	changes	increases
<b>C</b>	does not change	decreases
<b>D</b>	does not change	increases

- 12 The elements magnesium and sulfur each form doubly charged ions.

How do the atomic radii and ionic radii of these elements compare?

	atomic radius	ionic radius	atomic radius	ionic radius
<b>A</b>	Mg	>	Mg <sup>2+</sup>	S > S <sup>2-</sup>
<b>B</b>	Mg	>	Mg <sup>2+</sup>	S < S <sup>2-</sup>
<b>C</b>	Mg	<	Mg <sup>2+</sup>	S > S <sup>2-</sup>
<b>D</b>	Mg	<	Mg <sup>2+</sup>	S < S <sup>2-</sup>

- 13 Which graph correctly shows relative electronegativity plotted against relative atomic radius for the elements Na, Mg, Al and Si?



- 14 Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

Which property shows a **decrease** from magnesium to barium?

- A the rate of the reaction between the element and dilute hydrochloric acid
- B the solubility of the hydroxides
- C the solubility of the sulfates
- D the temperature of decomposition of the carbonates

- 15 Calcium oxide is added to water and the resulting mixture is filtered.

This filtrate is X.

When carbon dioxide is bubbled through filtrate X, a white precipitate is formed.

Which equation for this reaction of filtrate X with carbon dioxide is correct?

- A  $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$
- B  $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaO} + \text{H}_2\text{CO}_3$
- C  $2\text{CaO} + \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{Ca(OH)}_2$
- D  $\text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O}$
- 16 Element X reacts with cold, dilute, aqueous sodium hydroxide to form two different chlorine-containing products, Y and Z.

What are the oxidation states of chlorine in Y and Z?

	Y	Z
<b>A</b>	0	+1
<b>B</b>	0	+5
<b>C</b>	-1	+1
<b>D</b>	-1	+5

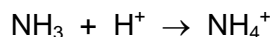
- 17 A powder is known to be either a single sodium halide or a mixture of two sodium halides. A sample of the powder was dissolved in water.

Aqueous silver nitrate was added, and a pale yellow precipitate was formed. When concentrated aqueous ammonia was then added, this precipitate partly dissolved leaving a darker yellow precipitate.

What might the powder be?

- A sodium bromide only
- B sodium iodide only
- C a mixture of sodium chloride and sodium bromide
- D a mixture of sodium chloride and sodium iodide

- 18 The ammonium ion is formed by the following reaction.



Which statement about the species involved in this reaction is correct?

- A The ammonia molecule contains a dative covalent bond.
  - B The ammonium ion is a Brønsted-Lowry base as it has accepted a proton.
  - C The H–N–H bond angle changes from 107° in ammonia to 90° in the ammonium ion.
  - D The number of electrons surrounding each nitrogen atom does not change.
- 19 A chemist took 2.00 dm<sup>3</sup> of nitrogen gas, measured under room conditions, and reacted it with a large volume of hydrogen gas to produce ammonia. Only 15.0% of the nitrogen gas reacted to produce ammonia.

Which mass of ammonia was formed?

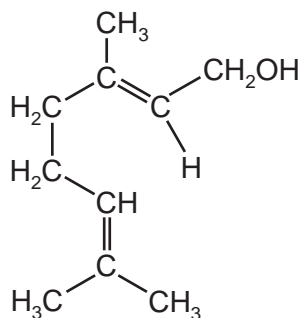
- A 0.213 g
  - B 0.425 g
  - C 1.42 g
  - D 2.83 g
- 20 A carbonyl compound **X** will react with HCN in the presence of NaCN to make a compound with  $M_r$  85. Compound **X** does **not** react with Fehling's reagent.

What is **X**?

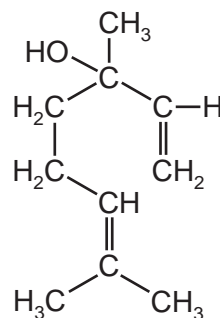
- A butanal
- B butanone
- C propanal
- D propanone



21 Geraniol and linalool are compounds found in some flower fragrances.



geraniol



linalool

Which statement is correct?

- A They are chain isomers of each other.
  - B They are geometrical isomers of each other.
  - C They are optical isomers of each other.
  - D They are positional isomers of each other.
- 22 Which equation represents the initiation step of the substitution reaction between methane and chlorine?
- A  $\text{CH}_4 \rightarrow \text{CH}_3\cdot + \text{H}\cdot$
  - B  $\text{CH}_4 \rightarrow \text{CH}_3^- + \text{H}^+$
  - C  $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$
  - D  $\text{Cl}_2 \rightarrow \text{Cl}^+ + \text{Cl}^-$
- 23 Aqueous sodium hydroxide reacts with 1-bromopropane to give propan-1-ol.

What should be included in a diagram of the first step in the mechanism?

- A a curly arrow from a lone pair on the  $\text{OH}^-$  ion to the  $\text{C}^{\delta+}$  atom of 1-bromopropane
- B a curly arrow from the  $\text{C}^{\delta+}$  atom of 1-bromopropane to the  $\text{OH}^-$  ion
- C a curly arrow from the C–Br bond to the C atom
- D the homolytic fission of the C–Br bond

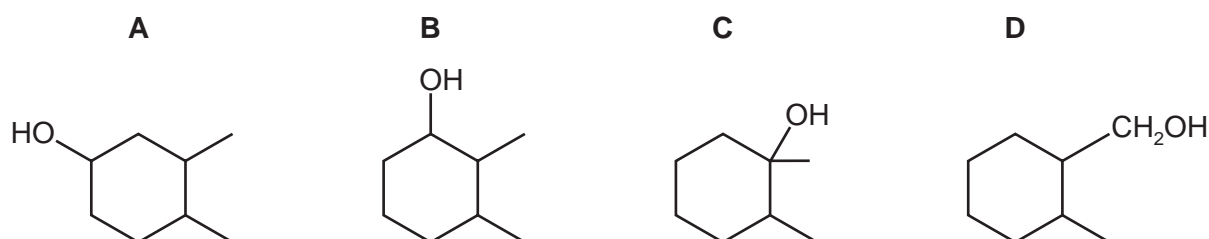
- 24 A sample of 2.76 g of ethanol was mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The required organic product was then collected by distillation.

The yield of product was 75.0%.

Which mass of product was collected?

- A 1.26 g      B 1.98 g      C 2.07 g      D 2.70 g
- 25 Compound X is a single, pure, optical isomer. X is heated with an excess of concentrated  $\text{H}_2\text{SO}_4$ . Only one organic product is formed.

What could X be?



- 26 2-bromo-2-methylpropane undergoes nucleophilic substitution when heated under reflux with an aqueous solution of sodium hydroxide.

Which row is correct?

	mechanism for this reaction	reason
A	$\text{S}_{\text{N}}1$	the hydroxide ion is helped in its approach to the central carbon atom by the methyl groups
B	$\text{S}_{\text{N}}1$	the intermediate carbocation is stabilised by the inductive effect of the methyl groups
C	$\text{S}_{\text{N}}2$	the hydroxide ion is hindered in its approach to the central carbon atom by the methyl groups
D	$\text{S}_{\text{N}}2$	the intermediate carbocation is destabilised by the inductive effect of the methyl groups

27  $\text{H}_2\text{NNHC}_6\text{H}_3(\text{NO}_2)_2$  is the structural formula of 2,4-DNPH.

Many, but not all, organic reactions need to be heated before reaction occurs.

Which reaction occurs at a good rate at room temperature (20 °C)?

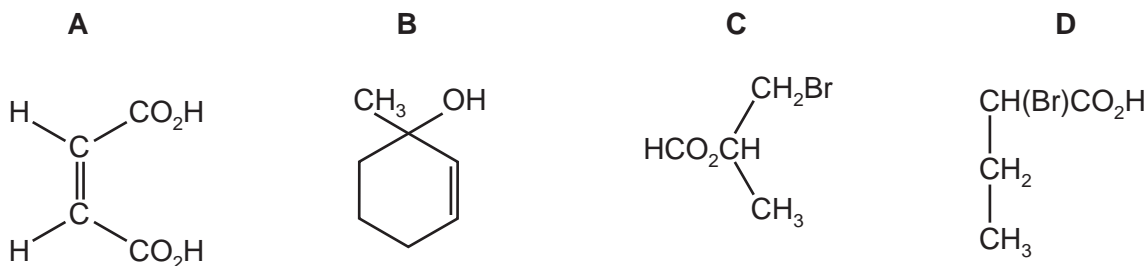
- A**  $\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_8\text{H}_{18} + \text{C}_2\text{H}_4$   
**B**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + \text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 + \text{HBr}$   
**C**  $\text{CH}_3\text{CH}_2\text{OH} + \text{KBr} \rightarrow \text{CH}_3\text{CH}_2\text{Br} + \text{KOH}$   
**D**  $(\text{CH}_3)_2\text{CO} + \text{H}_2\text{NNHC}_6\text{H}_3(\text{NO}_2)_2 \rightarrow (\text{CH}_3)_2\text{C}=\text{NNHC}_6\text{H}_3(\text{NO}_2)_2 + \text{H}_2\text{O}$

28 A carboxylic acid, P, has no possible chain isomers. It reacts with an alcohol, Q, that has only one positional isomer.

What could be the ester formed from a reaction between P and Q?

- A** butyl propanoate  
**B** ethyl butanoate  
**C** pentyl ethanoate  
**D** propyl pentanoate

29 Which compound is chiral and reacts with  $\text{Na}_2\text{CO}_3$  to give  $\text{CO}_2$ ?



30 Which compound, when hydrolysed, gives propanoic acid and propan-2-ol?

- A**  $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_3$   
**B**  $(\text{CH}_3)_2\text{CHCO}_2\text{CH}_2\text{CH}_3$   
**C**  $\text{CH}_3\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_3$   
**D**  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CO}_2\text{CH}(\text{CH}_3)\text{CH}_3$

## 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.

Use of the Data Booklet may be appropriate for some questions.

- 31** An isolated gaseous atom of element X has paired electrons in at least one of its 3d orbitals and has a filled 4s subshell.

What could be the identity of element X?

- 1 iron
- 2 gallium
- 3 copper

- 32** Which allotropes of carbon have a giant molecular structure?

- 1 buckminsterfullerene
- 2 diamond
- 3 graphite

- 33** Which statements about endothermic reactions are correct?

- 1 On the reaction pathway diagram the products of the reaction are lower than the reactants.
- 2 There is a net transfer of heat energy from the surroundings to the reacting system.
- 3 the total bond energies of the reactants > the total bond energies of the products

34 The rate of chemical reactions can be increased by the addition of a suitable catalyst.

For which reactions can a heterogeneous catalyst be used?

- 1  $\text{N}_2 + 3\text{H}_2 \rightleftharpoons 2\text{NH}_3$
- 2  $2\text{SO}_2 + \text{O}_2 \rightleftharpoons 2\text{SO}_3$
- 3  $2\text{NO} + 2\text{CO} \rightleftharpoons \text{N}_2 + 2\text{CO}_2$

35 Which chlorides, when added to water, can produce a solution with a pH of less than 5?

- 1  $\text{SiCl}_4$
- 2  $\text{AlCl}_3$
- 3  $\text{MgCl}_2$

36 Acid rain continues to be a problem.

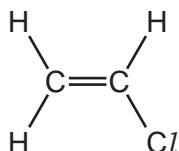
Which statements about acid rain are correct?

- 1 Acid rain is formed when oxides of nitrogen or oxides of sulfur react with water in the atmosphere.
- 2 Acid rain causes an increase in the concentration of heavy metal ions in water courses.
- 3 Nitrogen dioxide will catalyse the formation of  $\text{SO}_3$  from  $\text{SO}_2$  in the atmosphere.

37 Which compounds contain a chiral centre?

- 1 2-hydroxybutanoic acid
- 2 3-hydroxybutanoic acid
- 3 4-hydroxybutanoic acid

38 The diagram shows the monomer used to make polyvinyl chloride, PVC.



Assuming that one particular molecule of the polymer forms from  $n$  molecules of the monomer (where  $n$  is many thousands), which statements are correct?

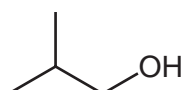
- 1 The relative molecular mass of this polymer molecule is approximately  $62.5n$ .
- 2 There are  $n$  chiral carbon atoms in this polymer molecule.
- 3 There are  $5n$   $\sigma$  bonds in one polymer molecule.

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.

**39** An organic compound, X, has the following skeletal formula.



X

Which statements about X are correct?

- 1 X is a primary alcohol.
- 2 X will dehydrate to give a single alkene.
- 3 X will undergo a substitution reaction with chloride ions.

**40** 2,2,4-trimethylpentanal is used in the manufacture of adhesives.

Which reagents would 2,2,4-trimethylpentanal react with?

- 1 2,4-dinitrophenylhydrazine reagent
- 2 Tollens' reagent
- 3 alkaline aqueous iodine

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