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Cambridge Assessment International Education

# Cambridge International AS & A Level

**CHEMISTRY** **9701/12**

Paper 1 Multiple Choice **February/March 2021**

**1 hour**

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data Booklet

**INSTRUCTIONS**

- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

**INFORMATION**

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **16** pages. Any blank pages are indicated.


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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.

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

**1** The table shows the numbers of protons, neutrons and electrons in four different particles, W, X, Y, and Z.

| | number of protons | number of neutrons | number of electrons |
|---|---|---|---|
| W | 32 | 40 | 32 |
| X | 32 | 40 | 34 |
| Y | 32 | 42 | 32 |
| Z | 34 | 40 | 34 |

Which pair represents the atoms of two isotopes of the same element?

**A** W and Y **B** W and Z **C** X and Y **D** X and Z

**2** Where in the Periodic Table is the element that has an outer electron shell arrangement of $4s^2 4p^3$?

| | Group | Period |
|---|---|---|
| **A** | 13 | 3 |
| **B** | 13 | 4 |
| **C** | 15 | 3 |
| **D** | 15 | 4 |

**3** Substance Q is a hydrocarbon. When 1.00 g of Q is completely burned, 3.22 g of carbon dioxide is produced.

What could be the identity of Q?

**A** cyclohexene

**B** cyclopentane

**C** ethene

**D** pentane

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**4** Originally, chemists thought indium oxide had the formula InO. By experiment they showed that 4.8 g of indium combined with 1.0 g of oxygen to produce 5.8 g of indium oxide. The $A_r$ of oxygen was known to be 16.

Which value for the $A_r$ of indium is calculated using these data?

**A** 38 **B** 77 **C** 115 **D** 154

**5** In which substance are the only intermolecular forces temporary dipole-induced dipole attractions?

**A** hydrogen chloride

**B** methanol

**C** octane

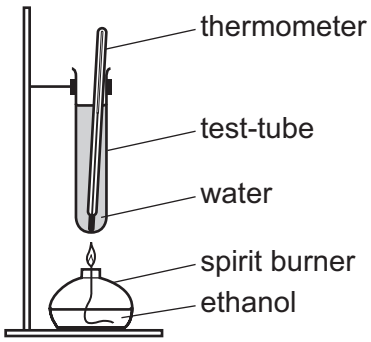
**D** water

**6** A solution contains 0.25 g of sulfur dioxide in 1.00 $dm^3$ of water.

Which volume of sulfur dioxide, measured at 50 °C and a pressure of $1 \times 10^5$ Pa, must be added to 1.00 $dm^3$ of water to produce this solution?

**A** 0.0162 $cm^3$ **B** 0.105 $cm^3$ **C** 16.2 $cm^3$ **D** 105 $cm^3$

**7** An experiment was performed to determine the enthalpy of combustion of ethanol.




The data collected are shown.

mass of water = $W$ g

mass of ethanol burned = $X$ g

temperature rise = $Y$ °C

molar mass of ethanol = $Z$ g $mol^{-1}$

specific heat capacity of water = 4.2 J $K^{-1}$ $g^{-1}$

Which expression can be used to calculate the enthalpy of combustion of ethanol in kJ $mol^{-1}$?

**A** $\frac{-4.2WYZ}{1000X}$ **B** $\frac{-4.2WYX}{1000Z}$ **C** $\frac{-4.2XYZ}{1000W}$ **D** $\frac{-4.2X(Y+273)Z}{1000W}$

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**[Turn over**

**8** $VO_2Cl$ reacts with NaI under acidic conditions.

$$2VO_2Cl + 2H_2SO_4 + 2NaI \rightarrow VOCl_2 + VOSO_4 + I_2 + Na_2SO_4 + 2H_2O$$

The oxidation state of $Cl$ is –1 in $VO_2Cl$ and in $VOCl_2$.

Which row about this reaction is correct?

| | vanadium | iodine |
|---|---|---|
| **A** | is oxidised | is oxidised |
| **B** | is oxidised | is reduced |
| **C** | is reduced | is oxidised |
| **D** | is reduced | is reduced |

**9** In which reaction is water behaving as a Brønsted–Lowry base?

**A** $H_2O + Na \rightarrow NaOH + \frac{1}{2}H_2$

**B** $H_2O + H_3PO_4 \rightarrow H_3O^+ + H_2PO_4^-$

**C** $H_2O + CaO \rightarrow Ca(OH)_2$

**D** $NH_3 + [Cu(H_2O)_6]^{2+} \rightarrow NH_4^+ + [Cu(H_2O)_5(OH)]^+$

**10** A large excess of marble chips is reacted with 25 $cm^3$ of 1.0 mol $dm^{-3}$ hydrochloric acid at 40 °C.

How is the result different when the reaction is repeated with 60 $cm^3$ of 0.5 mol $dm^{-3}$ hydrochloric acid at 40 °C?

**A** The reaction is faster and more of the products are made when the reaction is complete.

**B** The reaction is faster and less of the products are made when the reaction is complete.

**C** The reaction is slower and more of the products are made when the reaction is complete.

**D** The reaction is slower and less of the products are made when the reaction is complete.

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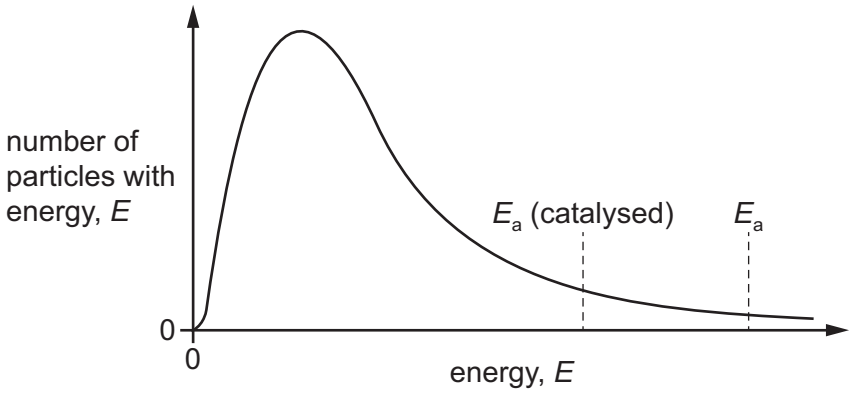
**11** The Boltzmann distribution curve for a gaseous mixture of ethene and hydrogen is shown. Nickel is an effective catalyst for the reaction that occurs.




How does the diagram appear if the same reaction mixture is at a higher temperature?

**A** The curve is unchanged.

**B** The values of both $E_a$ (catalysed) and $E_a$ decrease.

**C** The values of both $E_a$ (catalysed) and $E_a$ increase.

**D** The values of both $E_a$ (catalysed) and $E_a$ remain the same.

**12** Which observations are made when a sample of silicon chloride, $SiCl_4$, is added to a beaker of water?

**A** No visible change is observed.

**B** Steamy fumes and a precipitate are both observed.

**C** The appearance of a precipitate is the only observation.

**D** The appearance of steamy fumes is the only observation.

**13** Which row is correct?

| | statement | reason |
|---|---|---|
| **A** | The first ionisation energy of phosphorus is greater than that of magnesium. | electron is lost from a 3p orbital in both cases |
| **B** | The melting point of phosphorus is greater than that of magnesium. | phosphorus has more valence electrons than magnesium |
| **C** | The atomic radius of phosphorus is smaller than that of magnesium. | phosphorus has greater nuclear charge than magnesium |
| **D** | The electrical conductivity of phosphorus is smaller than that of magnesium. | bonding changes from ionic in magnesium to covalent in phosphorus |

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**14** Which row correctly describes one property of barium and one property of barium oxide?

| | observation when barium metal is added to water | pH of solution obtained when a spatula measure of BaO is added to 100 $cm^3$ of water |
|---|---|---|
| **A** | a few gas bubbles form on the metal surface | 8 |
| **B** | a few gas bubbles form on the metal surface | 13 |
| **C** | rapid effervescence is seen | 8 |
| **D** | rapid effervescence is seen | 13 |

**15** An anhydrous white salt, Z, is heated strongly for 30 minutes. A mixture of gases is given off. The solid remaining in the test-tube is then dissolved in a small volume of dilute hydrochloric acid. The addition of a few drops of dilute sulfuric acid to the test-tube causes a white precipitate to form.

Which substance could be Z?

**A** barium carbonate

**B** barium nitrate

**C** magnesium carbonate

**D** magnesium nitrate

**16** Chlorine gas is reacted with aqueous sodium hydroxide. The oxidation number of chlorine changes from 0 to –1 and also from 0 to +1.

Under which conditions does this reaction occur and what is the colour of the solid silver salt with chlorine in the oxidation state –1?

| | reaction conditions | colour of silver salt |
|---|---|---|
| **A** | cold, dilute alkali | white |
| **B** | cold, dilute alkali | yellow |
| **C** | hot, concentrated alkali | white |
| **D** | hot, concentrated alkali | yellow |

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**17** When concentrated sulfuric acid reacts with sodium iodide the products include sulfur, iodine, hydrogen sulfide and sulfur dioxide.

Which statement is correct?

**A** Hydrogen sulfide is the product of a reduction reaction.

**B** Iodide ions are stronger oxidising agents than sulfate ions.

**C** Sulfur atoms from the sulfuric acid are both oxidised and reduced.

**D** Sulfur atoms from the sulfuric acid are oxidised to make sulfur dioxide.

**18** NO, $NO_2$, CO and unburnt hydrocarbons are present in the exhaust gases of internal combustion engines. When catalytic converters are used to remove these compounds from the exhaust gases, redox reactions occur.

What happens to each compound in the catalytic converter?

| | NO | $NO_2$ | CO | unburnt hydrocarbons |
|---|---|---|---|---|
| **A** | oxidised | oxidised | reduced | oxidised |
| **B** | oxidised | oxidised | oxidised | oxidised |
| **C** | reduced | reduced | oxidised | oxidised |
| **D** | reduced | reduced | reduced | reduced |

**19** Methylamine, $CH_3NH_2$, has similar chemical properties to ammonia, $NH_3$. Methylamine reacts with hydrogen chloride to form a white crystalline salt, methylammonium chloride.

$$CH_3NH_2 + HCl \rightarrow CH_3NH_3^+Cl^-$$

A sample of methylammonium chloride is heated with aqueous sodium hydroxide.

What are the products?

**A** ammonia, sodium chloride and water

**B** ammonia, sodium hydrogencarbonate and sodium chloride

**C** methylamine, hydrogen chloride and water

**D** methylamine, sodium chloride and water

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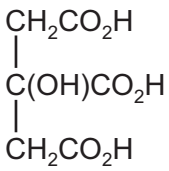
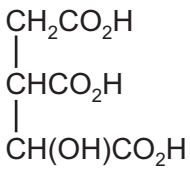
**20** The structures of citric acid and isocitric acid are shown.

citric acid



isocitric acid



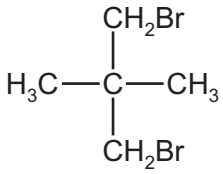
How many chiral centres does each acid possess?

| | citric acid | isocitric acid |
|---|---|---|
| **A** | 1 | 1 |
| **B** | 1 | 2 |
| **C** | 0 | 1 |
| **D** | 0 | 2 |

**21** How many tertiary alcohols have the molecular formula $C_6H_{14}O$?

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

**22** The diagram shows the structure of a bromo compound that may be formed by the reaction of bromine with a hydrocarbon.



Which row is correct?

| | type of reaction | mechanism |
|---|---|---|
| **A** | addition | electrophilic |
| **B** | addition | nucleophilic |
| **C** | substitution | nucleophilic |
| **D** | substitution | free-radical |

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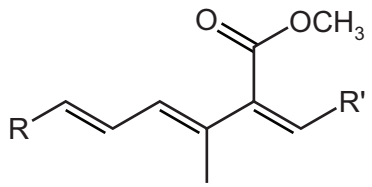
**23** Part of the structure of strobilurin is shown. R and R' are inert groups.

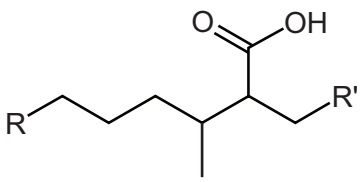
strobilurin



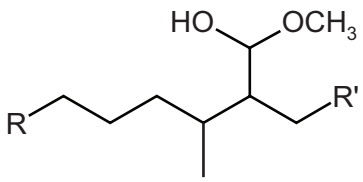

Strobilurin is warmed with aqueous sulfuric acid producing compound X. Compound X is then treated with hydrogen in the presence of a nickel catalyst producing compound Y.

What could be the structure of compound Y?

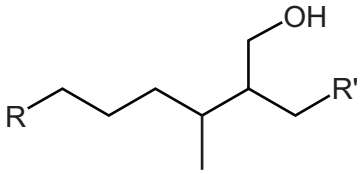
**A**



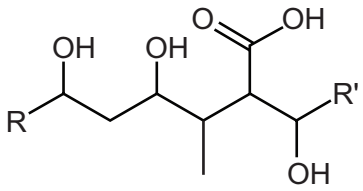

**B**




**C**




**D**




**24** Which compound produces a ketone when refluxed with an acidified solution of potassium dichromate(VI)?

**A** pentan-1-ol

**B** 2-methylbutan-1-ol

**C** 2-methylbutan-2-ol

**D** 3-methylbutan-2-ol

**25** Dibromopentanes can undergo 'double elimination' reactions to produce hydrocarbons.

$$2NaOH + C_5H_{10}Br_2 \rightarrow C_5H_8 + 2NaBr + 2H_2O$$

Which isomer produces only one hydrocarbon product?

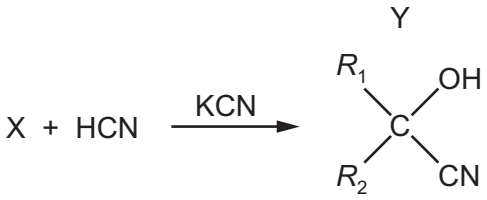
**A** 1,5-dibromopentane

**B** 1,4-dibromopentane

**C** 2,3-dibromopentane

**D** 2,4-dibromopentane

**26** The diagram shows the formation of compound Y from compound X in a chemical reaction. $R_1$ and $R_2$ are alkyl groups.




Which row about this reaction is correct?

| | mechanism | compound X |
|---|---|---|
| **A** | electrophilic addition | aldehyde |
| **B** | electrophilic addition | ketone |
| **C** | nucleophilic addition | ketone |
| **D** | nucleophilic addition | aldehyde |

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**27** In this question you can assume that $^{1}H$ and $^{3}H$ have the same chemical properties.

A sample of ethanal contains only one isotope of hydrogen, $^{1}H$.

It is reduced to compound Z, $C_2H_6O$, in a nucleophilic addition reaction using $NaBH_4$. All the hydrogen atoms in the $NaBH_4$ are the $^{3}H$ isotope.

$$CH_3CHO \xrightarrow{NaBH_4} \underset{\text{compound Z}}{C_2H_6O}$$

Compound Z is then oxidised back to ethanal and water.

$$C_2H_6O + [O] \rightarrow CH_3CHO + H_2O$$

Which statement about the final mixture of products is correct?

**A** Both ethanal and water contain $^{3}H$ atoms.

**B** Ethanal is the only product containing $^{3}H$ atoms.

**C** Neither ethanal nor water contain $^{3}H$ atoms.

**D** Water is the only product containing $^{3}H$ atoms.

**28** Ethanedioic acid has the formula $HO_2CCO_2H$.

What is the formula of aluminium ethanedioate?

**A** $Al C_2O_4$ **B** $Al(C_2O_4)_3$ **C** $Al_2C_2O_4$ **D** $Al_2(C_2O_4)_3$

**29** Which reaction gives butanoic acid as one of its products?

**A** acid hydrolysis of butyl ethanoate

**B** alkaline hydrolysis of butyl ethanoate

**C** acid hydrolysis of ethyl butanoate

**D** alkaline hydrolysis of ethyl butanoate

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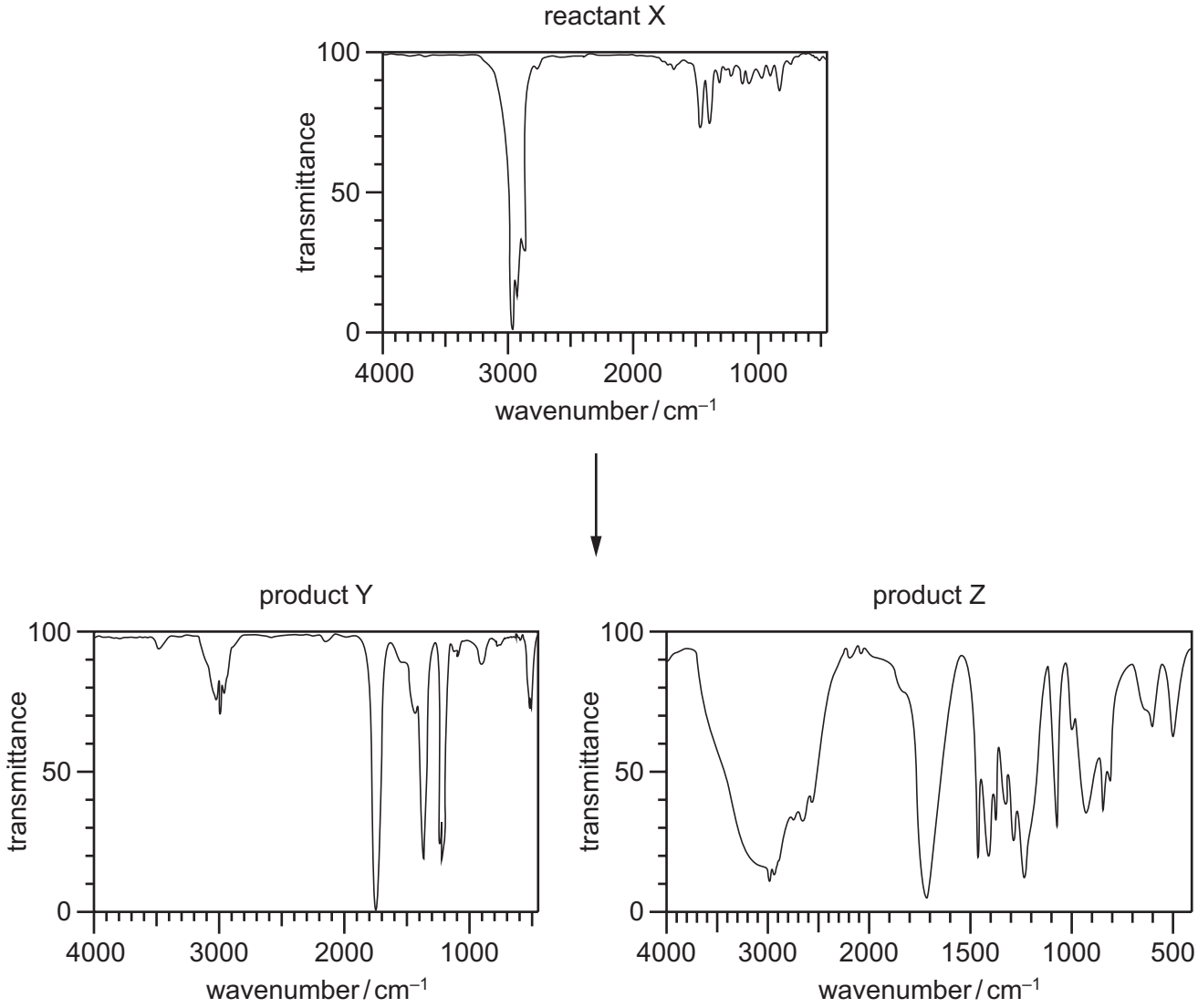
**30** When reactant X is treated with a suitable reagent, products Y and Z are formed. Infrared spectra of X, Y and Z are shown.




Which row could be correct?

| | X | Y | Z |
|---|---|---|---|
| **A** | 2,3-dimethylpent-2-ene | propanone | butanone |
| **B** | 2-methylpent-2-ene | propanone | propanoic acid |
| **C** | pent-2-ene | ethanoic acid | propanoic acid |
| **D** | propyl propanoate | propan-1-ol | propanoic acid |

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## 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.

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

**31** A sample of 17.15 mol HI(g) is in dynamic equilibrium with 2.27 mol $H_2(g)$ and 2.84 mol $I_2(g)$ in a volume of 1 $m^3$ at 764 K and 141 kPa.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

Two equilibrium constants, $K_c$ and $K_p$, can be calculated for this mixture.

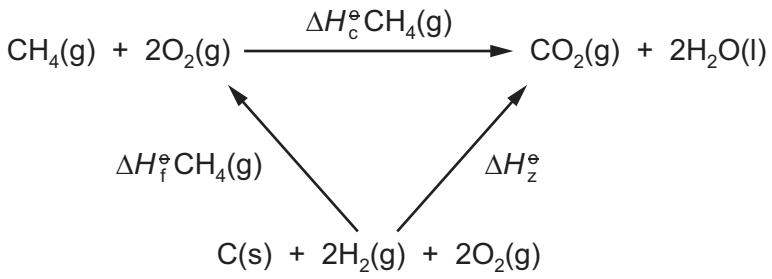
Which statements about the equilibrium constants for this mixture are correct?

**1** neither $K_c$ nor $K_p$ has any units

**2** $K_c = 45.6$

**3** $K_c > K_p$

**32** An energy cycle for the combustion of methane is shown.




Which expressions can be used to calculate the energy change, $\Delta H_z^{\ominus}$?

**1** $\Delta H_f^{\ominus}CH_4(g) + \Delta H_c^{\ominus}CH_4(g)$

**2** $\Delta H_c^{\ominus}C(s) + 2\Delta H_c^{\ominus}H_2(g)$

**3** $\Delta H_c^{\ominus}CO(g) + 2\Delta H_c^{\ominus}H_2(g)$

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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.

**33** Many gases do **not** obey the general gas equation at high pressures.

Why is this?

**1** At higher pressures the molecules have more energy.

**2** At higher pressures the volume of the molecules is a larger proportion of the total volume.

**3** At higher pressures the molecules experience greater intermolecular forces.

**34** Which species can accept a lone pair of electrons to form a coordinate (dative covalent) bond?

**1** $BF_3$

**2** $H^+$

**3** $CH_3^+$

**35** A sample containing *x* mol of $Al_2Cl_6$ is dissolved in water to give solution W.

In order to precipitate all of the aluminium as its hydroxide, *y* mol of sodium hydroxide are required.

More of the alkali is added to re-dissolve the precipitate, giving solution Z.

Which statements are correct?

**1** the initial pH of solution W is below 7

**2** $y = 3x$

**3** Z contains *x* mol of aluminium

**36** Nitrogen dioxide gas is produced when petrol is burned in car engines.

Which acids are made in the atmosphere as a result of this release of nitrogen dioxide into the air?

**1** $H_2SO_3$

**2** $H_2SO_4$

**3** $HNO_3$

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**37** In which reactions is the major product formed by a nucleophilic substitution reaction?

**1** bromoethane + potassium cyanide in ethanol

**2** bromoethane + ammonia in ethanol under pressure

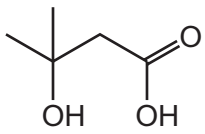
**3** bromoethane + hot concentrated sodium hydroxide in ethanol

**38** An excess of P reacts with Q, in the presence of concentrated sulfuric acid, to form R.

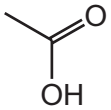
Effervescence is seen when a piece of sodium is added to pure R.

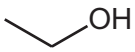
The structure of P is shown.

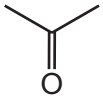
P




Which organic compounds could be compound Q?

**1** 


**2** 


**3** 


**39** Two carbonyl compounds have the molecular formula $C_3H_6O$.

Which reagents give **different** observations with these two compounds?

**1** acidified aqueous potassium manganate(VII)

**2** Fehling's reagent

**3** alkaline aqueous iodine

**40** An organic compound, T, does **not** fizz when aqueous sodium carbonate is added to it.

Compound T contains 27.6% by mass of oxygen.

What could be the identity of T?

**1** propanal

**2** ethyl butanoate

**3** 3-methylpentanoic acid

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