Cambridge International AS & A Level

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

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

Paper 1 Multiple Choice **October/November 2017**

**1 hour**

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

* 6 8 6 0 9 7 6 2 7 0 *

**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 **13** printed pages and **3** blank pages.


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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** In which pair do the atoms contain the same number of neutrons?

**A** $^{11}B$ and $^{12}C$

**B** $^{7}Li$ and $^{9}Be$

**C** $^{24}Mg$ and $^{28}Si$

**D** $^{14}N$ and $^{16}O$

**2** Two hydrocarbons have the formulae $C_WH_X$ and $C_YH_Z$. W, X, Y and Z represent different whole numbers.

$$\frac{W}{X} = \frac{Y}{Z}$$

Which row is correct when comparing the two hydrocarbons?

| | empirical formula | molecular formula | relative molecular mass |
|---|---|---|---|
| **A** | different | same | different |
| **B** | different | same | same |
| **C** | same | different | different |
| **D** | same | different | same |

**3** The airbags in cars contain sodium azide, $NaN_3$, and an excess of potassium nitrate, $KNO_3$.

In a car accident, the reactions shown occur, producing nitrogen. This causes the airbag to inflate rapidly.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas are produced **in total** when 1 mol of sodium azide, $NaN_3$, decomposes in an airbag?

**A** 1.5 **B** 1.6 **C** 3.2 **D** 4.0

**4** Ethane burns in oxygen to produce carbon dioxide and water vapour.

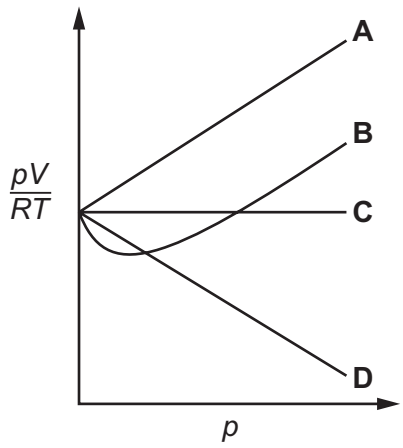
Which bond angles are present in the molecules of ethane and its combustion products?

| | ethane | combustion products |
|---|---|---|
| **A** | 90° | 104.5° and 180° |
| **B** | 90° | 109.5° and 120° |
| **C** | 109.5° | 104.5° and 180° |
| **D** | 109.5° | 109.5° and 180° |

**5** A sample of an ideal gas is contained at a constant temperature of 300 K in a gas syringe.

The pressure is increased and a graph of $\frac{pV}{RT}$ against pressure is plotted.

Which graph correctly represents the results?




**6** In calculating the enthalpy change, $\Delta H$, of an experiment involving solutions, the mass of the solution, $m$, specific heat capacity of the solution, $c$, and the temperature change, $\Delta T$, are needed.

$$\Delta T = T_{\text{final}} - T_{\text{initial}}$$

Which expression for $\Delta H$ is correct?

**A** $\Delta H = \frac{mc}{\Delta T}$ **B** $\Delta H = \frac{-mc}{\Delta T}$ **C** $\Delta H = mc\Delta T$ **D** $\Delta H = -mc\Delta T$

**7** The following data are needed for this question.

$\Delta H_f^\ominus (P_4O_{10}(s)) = -3012\,kJ\,mol^{-1}$

$\Delta H_f^\ominus (H_2O(l)) = -286\,kJ\,mol^{-1}$

$\Delta H_f^\ominus (H_3PO_4(s)) = -1279\,kJ\,mol^{-1}$

What is $\Delta H^\ominus$ for the reaction shown?

$$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(s)$$

**A** $-9844\,kJ\,mol^{-1}$

**B** $-388\,kJ\,mol^{-1}$

**C** $-97\,kJ\,mol^{-1}$

**D** $+2019\,kJ\,mol^{-1}$

**8** Which statement is **always** correct for an oxidation reaction?

**A** It involves the gain of oxygen by an element.

**B** For one reactant to be oxidised a different reactant must be reduced.

**C** The element or ion being oxidised will gain electrons.

**D** The oxidation number of the element being oxidised will increase.

**9** Nitrogen dioxide, $NO_2$, is a brown gas.

Dinitrogen tetroxide, $N_2O_4$, is a colourless gas.

An equilibrium is established between $NO_2$ and $N_2O_4$ in a closed vessel.

$$\underset{\text{brown}}{2NO_2(g)} \rightleftharpoons \underset{\text{colourless}}{N_2O_4(g)} \qquad \Delta H = -57\,kJ\,mol^{-1}$$

Which row describes the effects of changing conditions on the colour of an equilibrium mixture of $NO_2$ and $N_2O_4$?

| | increasing the pressure | increasing the temperature |
|---|---|---|
| **A** | colour becomes darker | colour becomes darker |
| **B** | colour becomes darker | colour becomes lighter |
| **C** | colour becomes lighter | colour becomes darker |
| **D** | colour becomes lighter | colour becomes lighter |

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

How will the result be 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 less of the products are made.

**B** The reaction is faster and more of the products are made.

**C** The reaction is slower and less of the products are made.

**D** The reaction is slower and more of the products are made.

**11** Which change alters the activation energy of a given reaction?

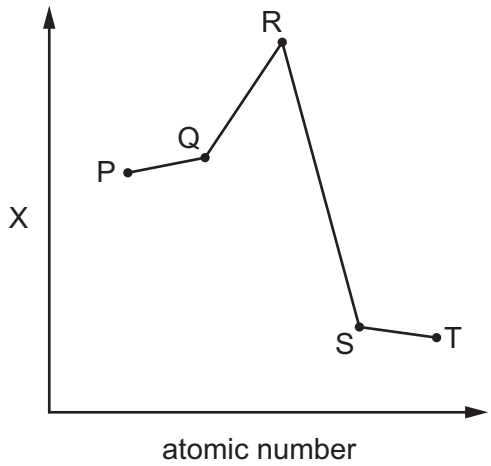
**A** adding a suitable catalyst

**B** changing the particle size of the reactants

**C** changing the pressure at which the reaction is carried out

**D** changing the temperature at which the reaction is carried out

**12** The relative magnitude of the property X of five elements is shown. P, Q, R, S and T are all in Period 3 and have consecutive atomic numbers.




Which row shows a correct pairing of property X and element R?

| | property X | element R |
|---|---|---|
| **A** | electrical conductivity | A*l* |
| **B** | electronegativity | Si |
| **C** | melting point | A*l* |
| **D** | second ionisation energy | Si |

**13** Element Z has a giant structure.

The chloride of Z reacts with water to give a solution with a pH less than 5.

Which row shows two elements which could be Z?

**A** aluminium, magnesium

**B** aluminium, silicon

**C** phosphorus, magnesium

**D** phosphorus, silicon

**14** Radium is an element below barium in Group 2 of the Periodic Table.

Which equation shows what happens when solid radium nitrate, $Ra(NO_3)_2$, is heated strongly?

**A** $Ra(NO_3)_2(s) \rightarrow RaO(s) + N_2O(g) + 2O_2(g)$

**B** $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 2N_2(g) + 5O_2(g)$

**C** $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 4NO_2(g) + O_2(g)$

**D** $4Ra(NO_3)_2(s) \rightarrow 2Ra_2O(s) + 8NO_2(g) + 3O_2(g)$

**15** Exactly 3.705 kg of substance Y are needed to neutralise 100 moles of $HCl(aq)$.

What could be substance Y?

**A** Ca **B** CaO **C** $Ca(OH)_2$ **D** $CaCO_3$

**16** In an experiment, 0.125 mol of chlorine gas, $Cl_2$, is reacted with an excess of cold, aqueous sodium hydroxide. One of the products is a compound of sodium, oxygen and chlorine.

Which mass of this product is formed?

**A** 9.31 g **B** 13.3 g **C** 18.6 g **D** 26.6 g

**17** Sodium bromide reacts with concentrated sulfuric acid.

Which observation will be made?

**A** A coloured vapour is produced.

**B** A purple solid is formed.

**C** A strong smell of $H_2S$ is detected.

**D** Yellow sulfur is formed.

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**18** The reaction of nitrogen and oxygen to produce oxides of nitrogen happens at high temperatures in car engines or lightning strikes during thunderstorms.

What is the main reason for these reactions requiring such high temperatures?

**A** the lack of reactivity of nitrogen, due to the half-filled 2p subshell in the nitrogen atom

**B** the lack of reactivity of nitrogen, due to the strength of the bond in $N_2$

**C** the lack of reactivity of oxygen, due to electron-electron repulsion in one of its 2p orbitals

**D** the lack of reactivity of oxygen, due to the strength of the bond in $O_2$

**19** **X** is a mixture of two compounds of Group 2 elements.

**X** undergoes thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture **X**?

**A** $MgCl_2$ and $CaCO_3$

**B** $MgCO_3$ and $Ca(NO_3)_2$

**C** $Mg(NO_3)_2$ and $Ca(NO_3)_2$

**D** MgO and CaO

**20** Which compound does **not** exhibit stereoisomerism?

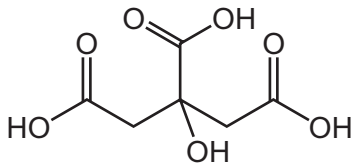
**A** $CH_3CHClCH_2CHO$

**B** $CH_3CHCHCH_3$

**C** $CH_2ClCH_2CCl_2H$

**D** $CHClCHCl$

**21** The diagram shows the skeletal formula of citric acid.



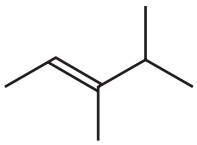

citric acid

What is the molecular formula of citric acid?

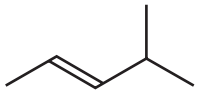
**A** $C_6H_8O_7$ **B** $C_6H_4O_7$ **C** $C_8H_8O_7$ **D** $C_{10}H_8O_7$

**22** Which compound would produce two different carboxylic acids when treated with hot, concentrated, acidified manganate(VII) ions?

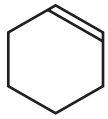
**A**



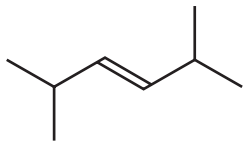
**B**



**C**



**D**



**23** Which types of bond are broken and formed in the addition polymerisation of alkenes?

| | type of bond broken | type of bond formed |
|---|---|---|
| **A** | $\pi$ only | $\sigma$ only |
| **B** | $\pi$ only | $\sigma$ and $\pi$ |
| **C** | $\sigma$ and $\pi$ | $\sigma$ only |
| **D** | $\sigma$ and $\pi$ | $\sigma$ and $\pi$ |

**24** 2,3-dimethylpent-2-ene, $(CH_3)_2C{=}C(CH_3)CH_2CH_3$, is treated with cold, dilute $KMnO_4$. The product of this reaction is treated with an excess of concentrated $H_2SO_4$ at 180 °C, giving a mixture of isomeric hydrocarbons with molecular formula $C_7H_{12}$.

What is the name of one of the isomeric hydrocarbons?

**A** 2,3-dimethylpenta-1,2-diene

**B** cis-2,3-dimethylpenta-1,3-diene

**C** 2,3-dimethylpenta-1,4-diene

**D** 3,4-dimethylpenta-1,3-diene

**25** Equal volumes of aqueous silver nitrate were added to separate small volumes of bromoethane and iodoethane in two test-tubes. The test-tubes were shaken.

Which row about the observations made for **bromoethane** is correct?

| | colour of precipitate | rate of reaction |
|---|---|---|
| **A** | cream | faster than for iodoethane |
| **B** | cream | slower than for iodoethane |
| **C** | yellow | faster than for iodoethane |
| **D** | yellow | slower than for iodoethane |

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

Which reaction occurs quickly at room temperature (20 °C)?

**A** $CH_3OH + PCl_5 \rightarrow CH_3Cl + POCl_3 + HCl$

**B** $CH_3CH_2Br + KCN \rightarrow CH_3CH_2CN + KBr$

**C** $CH_3CH_2OH \rightarrow C_2H_4 + H_2O$

**D** $CH_3CH_2CN + 2H_2O \rightarrow CH_3CH_2CO_2H + NH_3$

**27** When compound X is warmed with dilute, acidified potassium dichromate(VI) there is no colour change. X does not give an orange precipitate with 2,4-dinitrophenylhydrazine reagent.

What could X be?

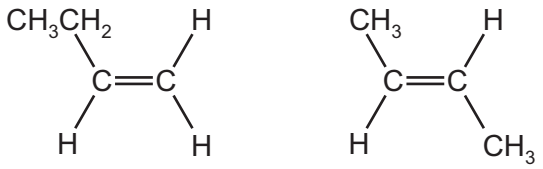
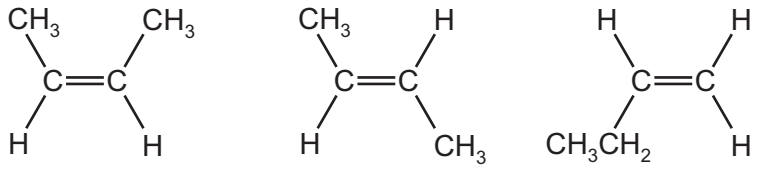
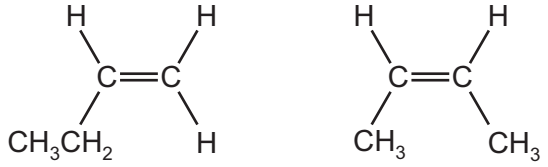
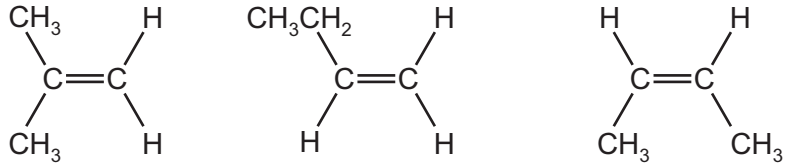
**A** butan-2-ol

**B** ethanal

**C** methylpropan-2-ol

**D** propanone

**28** What are the **only** structures formed when butan-2-ol is heated with concentrated $H_2SO_4$?

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

**29** Compound G

- has a chiral centre,
- gives a positive result with alkaline aqueous iodine,
- does not give a silver mirror with Tollens' reagent.

What could compound G be?

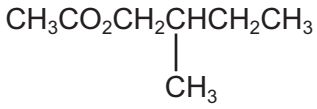
**A** 1-hydroxybutan-2-one

**B** 2-hydroxybutanal

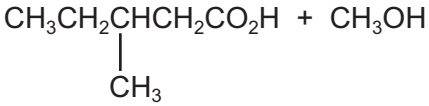
**C** 3-hydroxybutanal

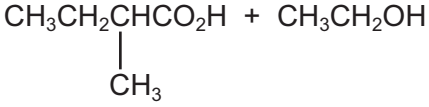
**D** 3-hydroxybutan-2-one

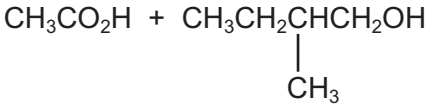
**30** An ester with an odour of banana has the following formula.

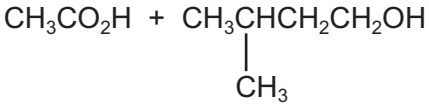


Which pair of reactants, under suitable conditions, will produce this ester?

**A** 

**B** 

**C** 

**D** 

## 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** In 2011 an international group of scientists agreed to add two new elements to the Periodic Table. Both elements had been made artificially and are called flerovium, F*l*, and livermorium, Lv.

| | F*l* | Lv |
|---|---|---|
| proton number | 114 | 116 |
| nucleon number | 289 | 292 |

From the information about atoms in the table, which statements are correct?

**1** One atom of Lv has one more neutron than one atom of F*l*.

**2** One $Fl^{2-}$ ion has the same number of electrons as one atom of Lv.

**3** One $Lv^{+}$ ion has the same number of electrons as one $Fl^{-}$ ion.

**32** The chlorine oxide free radical, C*l*O•, is produced by the reaction between chlorine atoms and ozone.

$$Cl\bullet + O_3 \rightarrow ClO\bullet + O_2$$

Which features are present in the chlorine oxide free radical?

**1** an odd number of electrons

**2** a single covalent bond

**3** a dative covalent bond from oxygen to chlorine

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** Hydrogen sulfide can be oxidised to form sulfur dioxide.

$$2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$$

Which statements are correct?

**1** The oxidation number of sulfur increases by 6.

**2** The oxidation number of oxygen increases by 2.

**3** The oxidation number of hydrogen decreases.

**34** Methanoic acid, $HCO_2H$, and hydrocyanic acid, HCN, can both behave as acids.

A solution of methanoic acid has a lower pH than a solution of hydrocyanic acid of the same concentration.

Which statements explain this?

**1** $HCO_2H$ molecules dissociate more fully than HCN molecules do.

**2** Each $HCO_2H$ molecule has two hydrogen atoms; each HCN molecule only has one.

**3** Methanoic acid is a weaker acid than hydrocyanic acid.

**35** Which statements correctly describe a trend on going down Group 2?

**1** Reactivity of the elements increases.

**2** First ionisation energy of the elements decreases.

**3** The hydroxides become more soluble in water.

**36** Modern cars are fitted with catalytic converters to reduce atmospheric pollution caused by unwanted reactions during the combustion of the fuel.

Which statements are correct?

**1** Carbon monoxide is oxidised to carbon dioxide in a catalytic converter.

**2** Catalytic converters have a very large surface area.

**3** Nitrogen dioxide is reduced to nitrogen monoxide in a catalytic converter.

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**37** Which statements are correct for an $S_N2$ mechanism?

**1** One bond is being broken at the same time as another bond is being formed.

**2** The formation of the intermediate involves the collision of two molecules or ions.

**3** A carbon atom in the transition state is bonded, either fully or partially, to five atoms.

**38** Bromoethane is heated under reflux with concentrated aqueous NaOH.

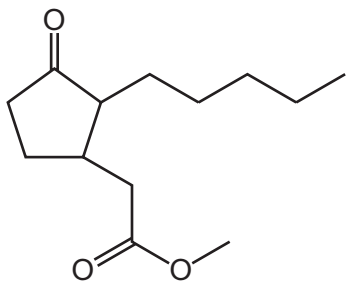
Which statements are correct?

**1** The major product is a primary alcohol.

**2** The major reaction is hydrolysis by an $S_N2$ mechanism.

**3** The major product would be the same if the NaOH is dissolved in ethanol.

**39** Compound M is an important ingredient in perfume.




compound M

M reacts with HCN.

Which statements about this reaction are correct?

**1** A small amount of NaOH will speed up the reaction.

**2** The reaction is initiated by the transfer of a proton to one of the C=O groups.

**3** Both of the C=O groups react with HCN.

**40** Carboxylic acids can be converted into their salts by a number of reactions at room temperature.

Which reactions would produce sodium butanoate and a gas?

**1** sodium carbonate + butanoic acid

**2** sodium + butanoic acid

**3** sodium hydroxide + butanoic acid

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