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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2012**

1 hour

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

* 6 6 9 9 3 1 2 2 8 8 *

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.

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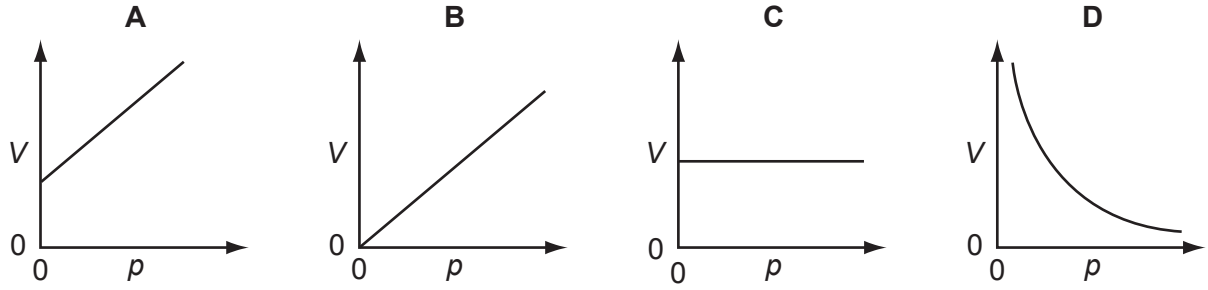
Section A

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

1 Which diagram shows the correct graph of V against p for a fixed mass of an ideal gas at constant temperature?



2 Which statement can be explained by intermolecular hydrogen bonding?

A Butane has a higher boiling point than propane.

B Hydrogen bromide forms an acidic solution when dissolved in water.

C SiH_4 has a higher boiling point than CH_4.

D Water has a higher boiling point than CH_4.

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

The volume of a sample of ammonia was measured at a temperature of 40 °C and a pressure of 95 kPa. The volume measured was $4.32 \times 10^{-5}\,m^3$.

What is the mass of the sample of ammonia?

A 2.7×10^{-5} g **B** 2.1×10^{-4} g **C** 2.7×10^{-2} g **D** 2.1×10^{-1} g

4 Aluminium is extracted by the electrolysis of a molten mixture containing aluminium oxide.

By a similar method, magnesium is extracted by the electrolysis of a molten mixture containing magnesium chloride.

Which statement about this electrolysis is correct?

A Chloride ions travel to the anode and are oxidised to chlorine gas.

B Chloride ions travel to the anode and are reduced to chlorine gas.

C Chloride ions travel to the cathode and are oxidised to chlorine gas.

D Chloride ions travel to the cathode and are reduced to chlorine gas.

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5 Ethyne, C_2H_2, completely combusts, as shown in the equation.

$$H—C{\equiv}C—H \;+\; 2\tfrac{1}{2}\,O{=}O \;\rightarrow\; H_2O \;+\; 2CO_2$$

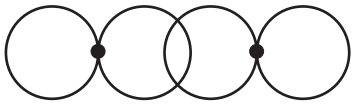
Using the average bond enthalpies in the table, what is the enthalpy change of combustion of ethyne?

bond	average bond enthalpy / kJ mol^{-1}
C — H	410
C ≡ C	840
O = O	496
C = O	740
O — H	460
C — O	360

A –980 kJ mol^{-1} **B** –540 kJ mol^{-1} **C** +540 kJ mol^{-1} **D** +980 kJ mol^{-1}

6 Which diagram represents the overlap of two orbitals which will form a π bond?

A



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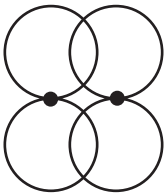

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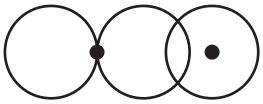
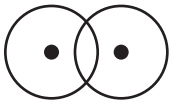


D



7 The table gives the successive ionisation energies for an element *X*.

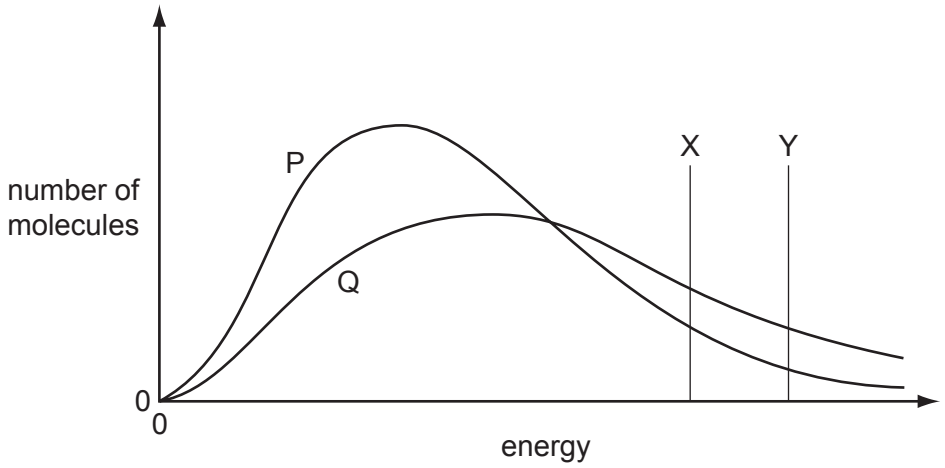
	1st	2nd	3rd	4th	5th	6th
ionisation energy / kJ mol^{-1}	950	1800	2700	4800	6000	12300

What could be the formula of the chloride of *X*?

A XCl **B** XCl_2 **C** XCl_3 **D** XCl_4

8 The gaseous compound Z decomposes on heating.

In the diagram below, Boltzmann distributions for Z at two different temperatures P and Q are shown. The lines X and Y indicate activation energies for the decomposition of Z with and without a catalyst.



Which curve and which line describe the decomposition of Z at a higher temperature and with a catalyst present?

	higher temperature	catalyst present
A	P	X
B	P	Y
C	Q	X
D	Q	Y

9 During steel-making the impurity P_4O_{10} is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate, $Ca_3(PO_4)_2$.

In this reaction, how many moles of calcium oxide react with one mole of P_4O_{10}?

A 1 **B** 1.5 **C** 3 **D** 6

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10 The enthalpy change of the neutralisation given below is $-114\,kJ\,mol^{-1}$.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

By using this information, what is the most likely value for the enthalpy change of the following neutralisation?

$$Ba(OH)_2(aq) + 2HCl(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$$

A $-57\,kJ\,mol^{-1}$ **B** $-76\,kJ\,mol^{-1}$ **C** $-114\,kJ\,mol^{-1}$ **D** $-228\,kJ\,mol^{-1}$

11 Which molecule is planar?

A C_2Cl_4 **B** C_3H_6 **C** C_3H_8 **D** NF_3

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

Why is the ionic radius of a sulfide ion larger than the ionic radius of a potassium ion?

A Ionic radius always decreases with increasing atomic number.

B Positive ions have smaller radii than negative ions.

C The potassium ion has more protons in its nucleus than the sulfide ion.

D The sulfide ion is doubly charged; the potassium ion is singly charged.

13 Mohr's salt is a pale green crystalline solid which is soluble in water. It contains two cations, one of which is Fe^{2+} and one anion which is SO_4^{2-}.

The identity of the second cation was determined by heating solid Mohr's salt with solid sodium hydroxide and a colourless gas was evolved. The gas readily dissolved in water giving an alkaline solution.

A grey-green solid residue was also formed which was insoluble in water.

What are the identities of the gas and the solid residue?

	gas	residue
A	NH_3	$Fe(OH)_2$
B	NH_3	Na_2SO_4
C	SO_2	$Fe(OH)_2$
D	SO_2	Na_2SO_4

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

When 3.00 g of an anhydrous nitrate of a Group II metal is decomposed, 1.53 g of gas is produced.

What is the nitrate compound?

A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

15 The reaction between KI and concentrated H_2SO_4 is a redox reaction.

$$5H_2SO_4 + 8KI \rightarrow 4K_2SO_4 + 4I_2 + H_2S + 4H_2O$$

What is the change in oxidation state of the element that is reduced?

A 1 **B** 4 **C** 6 **D** 8

16 Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

A barium carbonate

B barium chloride

C barium hydroxide

D barium sulfate

17 In the Haber process, the reaction between the two gaseous reactants requires the use of a catalyst that contains a transition element.

What is the metal and in what mole ratio do the gases react?

	metal	mole ratio
A	Fe	1 : 2
B	Fe	1 : 3
C	V	1 : 2
D	V	1 : 3

18 Which oxide, when mixed with water, will produce the solution with the lowest pH?

A CO_2 **B** Na_2O **C** P_4O_{10} **D** SiO_2

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19 Deposits of ammonium sulfate have been discovered in areas of high atmospheric pollution.

They are believed to arise from the following reaction.

$$SO_3 + H_2O + 2NH_3 \rightarrow (NH_4)_2SO_4$$

What does **not** occur in this reaction?

A acid / base neutralisation

B dative bond formation

C ionic bond formation

D oxidation / reduction

20 An organic compound X

- is unaffected by hot acidified potassium manganate(VII),
- reacts with ethanoic acid in the presence of concentrated sulfuric acid.

What is compound X?

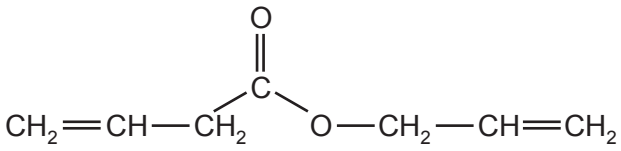
A $CH_3CO_2C_2H_5$

B $CH_3CH_2COCH_3$

C $(CH_3)_3COH$

D $CH_3CH_2CHOHCH_3$

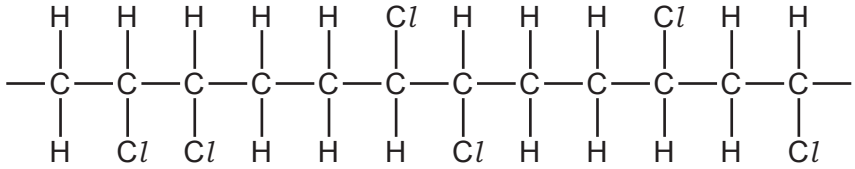
21 The diagram shows a molecule that has σ bonds and π bonds.



How many σ bonds are present in this molecule?

A 15 **B** 17 **C** 18 **D** 21

22 A molecule of a polymer contained the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

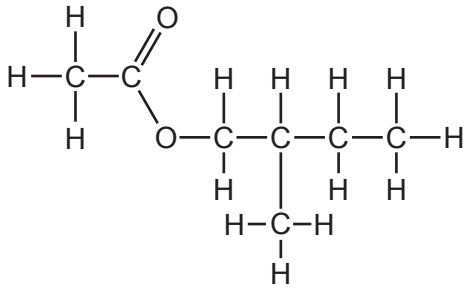
A CHCl=CHCl

B CH_2=CHCl

C CH_3CCl=CHCl

D CH_3CCl=CH_2

23 Bees use 2-methylbutyl ethanoate as an 'alarm' pheromone to alert other bees.



2-methylbutyl ethanoate

Which starting materials would be required to synthesise 2-methylbutyl ethanoate?

A CH_3CH_2OH and $CH_3CH_2CH(CH_3)CO_2H$

B CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2OH$

C CH_3CH_2OH and $CH_3CH_2CH(CH_3)CH_2CO_2H$

D CH_3CO_2H and $CH_3CH_2CH(CH_3)CH_2CO_2H$

24 Complete combustion of compound **X** produces carbon dioxide and water only. **X** produces steamy fumes with PCl_5. **X** does not give any visible product with 2,4-dinitrophenylhydrazine reagent.

What can be deduced with certainty from this information?

A **X** is a carboxylic acid.

B **X** is a hydrocarbon.

C **X** is an alcohol.

D **X** is not an aldehyde.

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

2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI) and the desired organic product was collected by immediate distillation under gentle warming. The yield of product was 70.0 %.

What mass of product was collected?

A 1.54 g **B** 1.61 g **C** 2.10 g **D** 2.20 g

26 Which pair of reactions *could* have the same common intermediate?

W $CH_3CH_2CH_3 \rightarrow$ intermediate $\rightarrow (CH_3)_2CHCN$

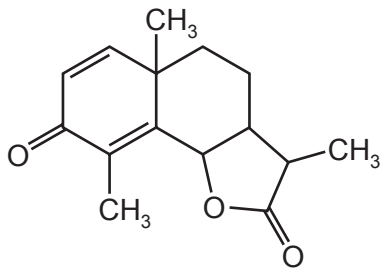
X $CH_3CH(OH)CH_3 \rightarrow$ intermediate $\rightarrow (CH_3)_2C(OH)CN$

Y $CH_3CH{=}CH_2 \rightarrow$ intermediate $\rightarrow CH_3CH(OH)CH_3$

Z $CH_3CO_2CH_2CH_2CH_3 \rightarrow$ intermediate $\rightarrow CH_3CH_2CH_2Br$

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

27 Santonin is a drug that was once widely used to expel parasitic worms from the body.



santonin

When santonin is first treated with warm dilute H_2SO_4, and then the product of this reaction is treated with cold acidified $KMnO_4$, a final product **X** is obtained.

How many atoms of hydrogen in each molecule of product **X** can be displaced with sodium metal?

A 2 **B** 4 **C** 5 **D** 6

28 Which compound is optically active and could also be oxidised to a ketone?

A 2-methylbutan-1-ol

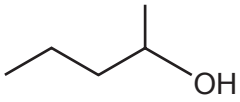
B 3-methylhexan-3-ol

C 3-methylpentan-2-ol

D propan-2-ol

29 What is the skeletal formula of 2-methylpentan-1-ol?

A



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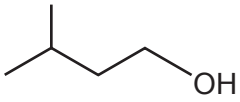

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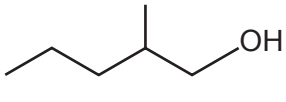

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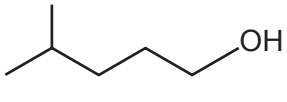
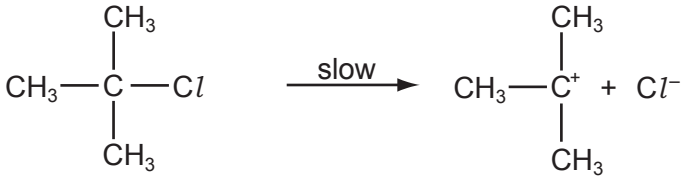
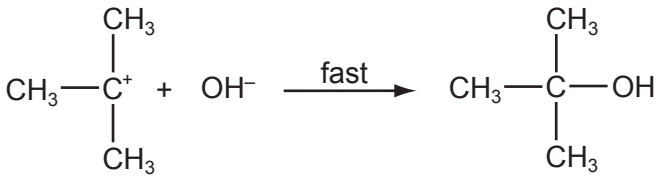


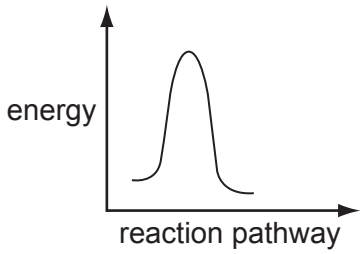
30 A possible mechanism for the exothermic hydrolysis of 2-chloro-2-methylpropane is shown.



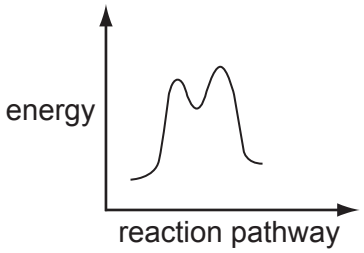


Which diagram represents the reaction pathway diagram for this mechanism?

A



B



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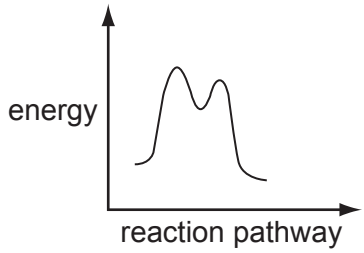

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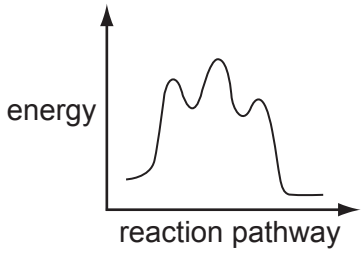

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Section B

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.

31 How may nitrogen exist in compounds?

1 bonded by a triple covalent bond

2 as part of a cation

3 in an oxidation state of +5

32 The phosphide ion $^{31}_{15}P^{3-}$ and sulfide ion $^{32}_{16}S^{2-}$ have the same number of which sub-atomic particles?

1 neutrons

2 electrons

3 protons

33 Which substances have a giant structure?

1 calcium oxide

2 calcium

3 baked clay found in crockery

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.

34 An element X and compound YZ react separately with acid as shown.

$$X(s) + 2H^+(aq) \rightarrow X^{2+}(aq) + H_2(g)$$

$$YZ(s) + 2H^+(aq) \rightarrow Y^{2+}(aq) + H_2Z(g)$$

When 1.0 g of either X or YZ is reacted with an excess of acid, the total volume of gas formed is the same.

Which statements are correct?

1 $A_r(X) = M_r(YZ)$

2 X and Y are metals.

3 X and Y must both be in the same Group of the Periodic Table.

35 In the gas phase, aluminium chloride exists as the dimer, Al_2Cl_6.

By using this information, which of the following are structural features of the Al_2Cl_6 molecule?

1 Each aluminium atom is surrounded by four chlorine atoms.

2 There are twelve non-bonded electron pairs in the molecule.

3 Each aluminium atom contributes electrons to four covalent bonds.

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36 The table describes some of the chemistry and thermodynamic properties of the halogens.

process	name and symbol of quantity
$2HX(g) \rightarrow H_2(g) + X_2(g)$	enthalpy change of reaction, $\Delta H^{\ominus}$
$H_2(g) + X_2(g) \rightleftharpoons 2HX(g)$	equilibrium constant, K_p
$X(g) \rightarrow X^+(g) + e^-$	ionisation energy, $\Delta H_i^{\ominus}$

Which statements about the relative values of these quantities are correct?

1 $\Delta H^{\ominus}$ for HCl > $\Delta H^{\ominus}$ for HBr

2 K_p for HBr > K_p for HI

3 $\Delta H_i^{\ominus}$ for I > $\Delta H_i^{\ominus}$ for Cl

37 Chloroethane can be formed from bromoethane in two steps.

$$C_2H_5Br \xrightarrow{\text{step X}} C_2H_5OH \xrightarrow{\text{step Y}} C_2H_5Cl$$

Which statements about these steps are correct?

1 Hot aqueous sodium hydroxide is the reagent in step X.

2 $SOCl_2$ is the reagent in step Y.

3 Step X is a substitution reaction.

38 Which pairs of reagents will react together in a redox reaction?

1 CH_3CHO + Fehling's reagent

2 CH_4 + Cl_2

3 CH_3COCH_3 + Tollens' reagent

39 An organic compound, **X**, will react with calcium metal to produce a salt with the empirical formula $CaC_4H_4O_4$.

What could be the identity of **X**?

1 ethanoic acid

2 butanedioic acid

3 2-methylpropanedioic acid

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 Which changes in bonding occur during the reaction of ethanal and hydrogen cyanide?

1 A carbon-carbon bond is formed.

2 A carbon-hydrogen bond is broken.

3 A carbon-nitrogen bond is broken.

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