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

CHEMISTRY **9701/13**

Paper 1 Multiple Choice **October/November 2011**

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 **13** printed pages and **3** 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 *Use of the Data Booklet is relevant to this question.*

Lead(IV) chloride will oxidise bromide ions to bromine. The Pb^{4+} ions are reduced to Pb^{2+} ions in this reaction.

If 6.980 g of lead(IV) chloride is added to an excess of sodium bromide solution, what mass of bromine would be produced?

A 0.799 g **B** 1.598 g **C** 3.196 g **D** 6.392 g

2 Which element has an equal number of electron pairs and of unpaired electrons within orbitals of principal quantum number 2?

A beryllium

B carbon

C nitrogen

D oxygen

3 Three elements, **X**, **Y** and **Z**, have the physical properties shown in the table.

element	melting point / °C	boiling point / °C	density / g cm^{-3}
X	–7	59	3.12
Y	98	883	0.97
Z	649	1107	1.74

What could be the identities of **X**, **Y** and **Z**?

	X	**Y**	**Z**
A	Br_2	A*l*	Si
B	Br_2	Na	Mg
C	I_2	Mg	Na
D	I_2	Si	K

4 At room temperature and pressure chlorine does not behave as an ideal gas.

At which temperature and pressure would the behaviour of chlorine become more ideal?

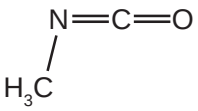
	pressure /kPa	temperature /K
A	50	200
B	50	400
C	200	200
D	200	400

5 Methyl isocyanate, CH_3NCO, is a toxic liquid which is used in the manufacture of some pesticides.

In the methyl isocyanate molecule, the sequence of atoms is $H_3C—N=C=O$.

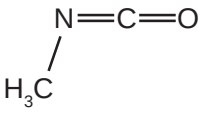
What is the approximate angle between the bonds formed by the N atom?

A



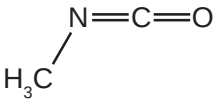
104°

B



109°

C



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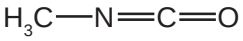
D



180°

6 When chlorine and aqueous sodium hydroxide are heated together the following overall reaction occurs.

$$3Cl_2(aq) + 6NaOH(aq) \rightarrow 5NaCl(aq) + NaClO_3(aq) + 3H_2O(l)$$

What are the oxidation numbers for chlorine in each of the following species?

	Cl_2	$NaCl$	$NaClO_3$
A	0	+1	–5
B	+2	–1	+3
C	0	–1	+5
D	–2	+1	–3

7 The standard enthalpy change for the reaction

$$2NF_3(g) \rightarrow 2N(g) + 6F(g) \qquad \text{is } \Delta H^{\ominus} = +1668\,\text{kJ}$$

What is the bond energy of the N–F bond?

A $-556\,\text{kJ mol}^{-1}$

B $-278\,\text{kJ mol}^{-1}$

C $+278\,\text{kJ mol}^{-1}$

D $+556\,\text{kJ mol}^{-1}$

8 When gaseous iodine is heated with hydrogen at 450 °C, an equilibrium is established.

$$\underset{\text{colourless}}{H_2(g)} + \underset{\text{purple}}{I_2(g)} \rightleftharpoons \underset{\text{colourless}}{2HI(g)} \qquad \Delta H = +53\,\text{kJ mol}^{-1}$$

Which change of conditions will cause the purple colour of the equilibrium mixture to become paler?

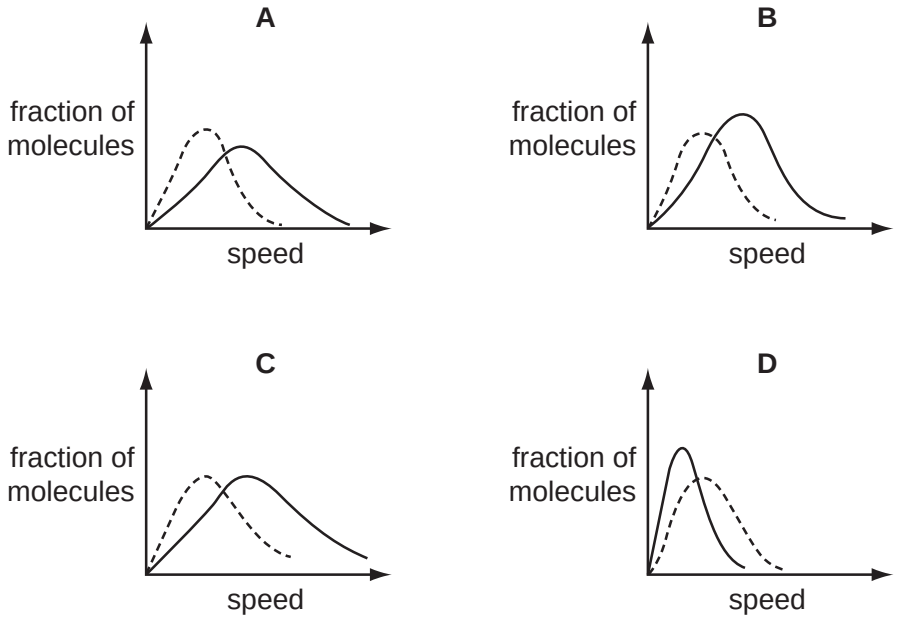
A decrease in pressure

B decrease in temperature

C increase in pressure

D increase in temperature

9 Which solid-line curve most accurately represents the distribution of molecular speeds in a gas at 500 K if the dotted-line curve represents the corresponding distribution for the same gas at 300 K?



10 Sulfur dioxide is used as a preservative in wine making.

The following equations describe how sulfur dioxide dissolves.

$$H_2O + SO_2 \rightleftharpoons HSO_3^- + H^+$$

$$HSO_3^- + H^+ \rightleftharpoons SO_3^{2-} + 2H^+$$

Which statement about these two reactions is correct?

A HSO_3^- acts as a base.

B SO_2 acts as an oxidising agent.

C SO_3^{2-} acts as an acid.

D SO_3^{2-} acts as a reducing agent.

11 Butanedioate ions can be dehydrogenated to form *trans*-butenedioate ions. The enzyme fumarase speeds up this reaction.

Why does fumarase speed up this reaction?

A Fumarase is a protein.

B Fumarase is effective at body temperature.

C Fumarase lowers the activation energy of the dehydrogenation reaction.

D The enzyme fumarase is specific for this dehydrogenation reaction.

12 An aqueous solution was prepared containing 1.0 mol of $AgNO_3$ and 1.0 mol of $FeSO_4$ in 1.00 dm^3 of water. When equilibrium was established, there was 0.44 mol of $Ag^+(aq)$ in the mixture.

$$Ag^+(aq) + Fe^{2+}(aq) \rightleftharpoons Ag(s) + Fe^{3+}(aq)$$

What is the numerical value of K_c?

A 0.35 **B** 0.62 **C** 1.62 **D** 2.89

13 Which element shows the greatest tendency to form some covalent compounds?

A aluminium

B magnesium

C neon

D potassium

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

A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

A magnesium

B calcium

C strontium

D barium

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

A significant contribution to atmospheric carbon dioxide levels comes from the thermal decomposition of limestone, in the manufacture of cement and of lime for agricultural purposes.

Cement works roast 1000 million tonnes of limestone per year and a further 200 million tonnes is roasted in kilns to make lime.

What is the total annual mass output of carbon dioxide (in million tonnes) from these two processes?

A 440 **B** 527 **C** 660 **D** 880

16 Why do the halogens become less volatile as Group VII is descended?

A The halogen-halogen bond energy decreases.

B The halogen-halogen bond length increases.

C The number of electrons in each molecule increases.

D The van der Waals' forces between molecules become weaker.

17 Aqueous sodium chloride (brine) is electrolysed by using inert electrodes in a cell which is stirred so that products of electrolysis react with each other. The cell is kept cold.

Which pair of substances is among the major products?

A hydrogen and chlorine

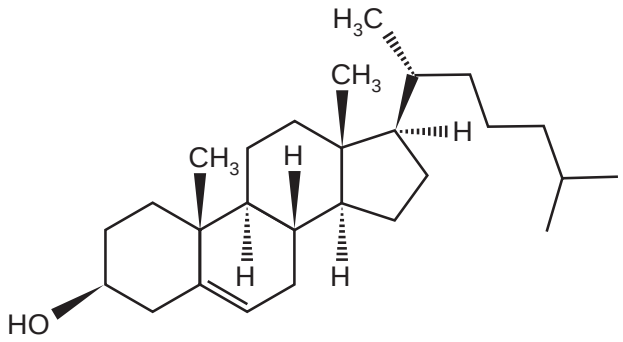
B hydrogen and sodium chlorate(I)

C hydrogen and sodium chlorate(V)

D sodium hydroxide and chlorine

18 This question should be answered by considering the reactions of $KMnO_4$ with different functional groups under the stated conditions.

The diagram shows the structure of the naturally-occurring molecule cholesterol.



cholesterol

Separate oxidation reactions are carried out using different conditions.

- cold, dilute acidified $KMnO_4$
- hot, concentrated acidified $KMnO_4$

Which statements about the **products** formed are correct?

	cold, dilute acidified $KMnO_4$: number of hydroxy groups present	hot, concentrated acidified $KMnO_4$: number of 6-membered rings remaining
A	1	2
B	1	3
C	3	2
D	3	3

19 Which reaction is endothermic?

A $2HBr \rightarrow H_2 + Br_2$

B $N_2 + 3H_2 \rightarrow 2NH_3$

C $2SO_2 + O_2 \rightarrow 2SO_3$

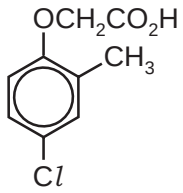
D $SO_3 + H_2O \rightarrow H_2SO_4$

20 Total removal of the pollutant sulfur dioxide, SO_2, is difficult, both for economic and technical reasons. The quantities emitted from furnace chimneys can be lowered by using desulfurisation plants. The gases are scrubbed (washed) with calcium hydroxide to remove the SO_2.

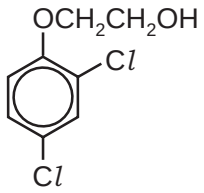
What is the main product formed **initially**?

A $Ca(HSO_4)_2$ **B** CaS **C** $CaSO_3$ **D** $CaSO_4$

21 **Y** and **Z** are two widely-used selective weed killers.



Y



Z

Which reagent will distinguish **Y** from **Z**?

A acidified $AgNO_3(aq)$

B Fehling's solution

C Na

D $Na_2CO_3(aq)$

22 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 1-bromobutane?

A attack by a nucleophile on a carbon atom with a partial positive charge

B heterolytic bond fission and attack by a nucleophile on a carbocation

C homolytic bond fission and attack by an electrophile on a carbanion

D homolytic bond fission and attack by a nucleophile on a carbocation

23 In the general formula of which class of compound, is the ratio of hydrogen atoms to carbon atoms the highest?

A alcohols

B aldehydes

C carboxylic acids

D halogenoalkanes

24 Many different compounds have been used in aerosol sprays, refrigerators and in making foamed plastics.

Which compound will cause the **most** ozone depletion?

A CCl_3F

B $CH_2FCHClF$

C $CH_3CH_2CH_2CH_3$

D N_2O

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

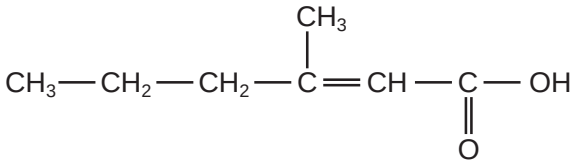
2.76 g of ethanol were mixed with an excess of aqueous acidified potassium dichromate(VI). The reaction mixture was then boiled under reflux for one hour. The organic product was then collected by distillation.

The yield of product was 75.0 %.

What mass of product was collected?

A 1.98 g **B** 2.07 g **C** 2.70 g **D** 4.80 g

26 An unpleasant smelling chemical produced in the human armpit is 3-methylhex-2-enoic acid.



If this compound is reacted with a cold, dilute, acidified solution of potassium manganate(VII), how many chiral centres will be produced?

A 0 **B** 1 **C** 2 **D** 3

27 Energy is released in the human body by the oxidation of glucose in a complex sequence of reactions. Part of this sequence is the Krebs cycle. One reaction in the Krebs cycle is the conversion of fumaric acid into malic acid.

$$HO_2CCH{=}CHCO_2H \rightarrow HO_2CCH(OH)CH_2CO_2H$$

fumaric acid malic acid

Which reagents could achieve this transformation in the laboratory?

A acidified $KMnO_4$

B Br_2(aq) followed by hot NaOH(aq)

C H_2O with Pt catalyst

D steam with H_2SO_4

28 A reaction between chlorine and propane in ultraviolet light produces two isomeric monochloropropanes, C_3H_7Cl, as products.

Which information about this reaction is correct?

	type of bond fission in initiation step	expected ratio of 1-chloropropane to 2-chloropropane produced
A	heterolytic	1 : 1
B	heterolytic	3 : 1
C	homolytic	1 : 1
D	homolytic	3 : 1

29 Which pair of substances could react to give the ester $CH_3CH_2CO_2CH_3$?

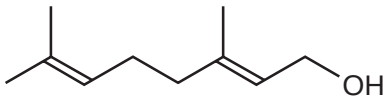
A ethanol and ethanoic acid

B methanol and ethanoic acid

C methanol and propanoic acid

D propan-1-ol and methanoic acid

30 Geraniol is a constituent of some perfumes.



geraniol

Which statement about geraniol is **not** correct?

A Geraniol causes hot acidified potassium dichromate(VI) to change colour from orange to green.

B Geraniol decolourises bromine water.

C There are three methyl groups and three methylene (CH_2) groups in geraniol.

D There are two pairs of *cis-trans* isomers of geraniol.

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 The definitions of many chemical terms can be illustrated by chemical equations.

Which terms can be illustrated by an equation that shows the formation of a positive ion?

1 first ionisation energy

2 heterolytic fission

3 enthalpy change of atomisation

32 The three statements that follow are all true.

Which of these can be explained, at least in part, by reference to hydrogen bonding?

1 At 0 °C ice floats on water.

2 The boiling point of propan-2-ol is 82 °C. The boiling point of propanone is 56 °C.

3 At 20 °C propanone and propanal mix completely.

33 Which of the halide ions, chloride, bromide or iodide, acts as a reducing agent when its sodium salt reacts with concentrated sulfuric acid?

1 at least one of Cl , Br and I

2 at least two of Cl , Br and I

3 all three of Cl , Br and I

34 Why does aluminium chloride, Al_2Cl_6, sublime at the relatively low temperature of 180 °C?

1 The intermolecular forces between the Al_2Cl_6 molecules are weak.

2 The co-ordinate bonds between aluminium and chlorine are weak.

3 The covalent bonds between aluminium and chlorine are weak.

[Turn over

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.

35 A farmer spreads lime on land which has already been treated with an ammonium nitrate fertiliser.

Which reactions will occur in the treated soil?

1 $Ca(OH)_2 + 2NH_4^+(aq) \rightarrow Ca^{2+}(aq) + 2NH_3 + 2H_2O$

2 $Ca(OH)_2 + 2H^+(aq) \rightarrow Ca^{2+}(aq) + 2H_2O$

3 $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

36 In a car engine, non-metallic element X forms a pollutant oxide Y.

Further oxidation of Y to Z occurs spontaneously in the atmosphere. In this further oxidation, 1 mol of Y reacts with 0.5 mol of gaseous oxygen.

Which statements about X, Y and Z are correct?

1 X forms a basic hydride.

2 Y is a diatomic molecule.

3 Z is a polar molecule.

37 **X** is an organic compound. **X** gives a precipitate with aqueous silver nitrate. Some or all of this precipitate remains undissolved when an excess of dilute aqueous ammonia is added.

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

1 2-chlorobutane

2 2-bromobutane

3 iodomethane

38 On acid hydrolysis, which compounds produce propanoic acid?

1 $CH_3CH_2CO_2CH_3$

2 $CH_3CH_2CH_2CN$

3 $CH_3CH_2CH_2Cl$

39 Disaccharides, $C_{12}H_{22}O_{11}$, are important in the human diet. For example, sucrose is found in pastries and lactose occurs in milk products.

Both of these compounds can be hydrolysed.

$$\underset{\text{sucrose}}{} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

$$\underset{\text{lactose}}{} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{galactose}}{CH_2OH(CHOH)_4CHO}$$

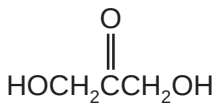
Which statements about these hydrolysis products are correct?

1 Glucose and fructose have structural isomers.

2 Glucose and galactose are optical isomers.

3 Glucose and galactose are ketones.

40 DHA is a colourless liquid which reacts with protein in skin to cause it to darken. It has the structure shown.



DHA

Which observations would be made when testing this substance?

1 Hydrogen is produced when sodium is added.

2 A coloured precipitate is produced when 2,4-dinitrophenylhydrazine reagent is added.

3 A silver precipitate is produced when Tollens' reagent is added.

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