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

CHEMISTRY **9701/12**

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

2652326564

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 and **3** blank pages.

© UCLES 2011

Section A

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

1 In the Haber process for the manufacture of ammonia, why is the heterogeneous catalyst iron in a finely divided state?

A to increase its surface area

B to produce the maximum reduction in the activation energy

C to reduce its loss during the reaction

D to reduce its surface area

2 The following equations the letters **W**, **X**, **Y** and **Z** all represent whole numbers.

When correctly balanced, which equation requires one of letters **W**, **X**, **Y** or **Z** to be 5?

A $\mathbf{W}C_3H_7COOH + \mathbf{X}O_2 \rightarrow \mathbf{Y}CO_2 + \mathbf{Z}H_2O$

B $\mathbf{W}C_4H_8 + \mathbf{X}O_2 \rightarrow \mathbf{Y}CO_2 + \mathbf{Z}H_2O$

C $\mathbf{W}H_3PO_4 + \mathbf{X}NaOH \rightarrow \mathbf{Y}Na_2HPO_4 + \mathbf{Z}H_2O$

D $\mathbf{W}NH_3 + \mathbf{X}O_2 \rightarrow \mathbf{Y}N_2 + \mathbf{Z}H_2O$

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

From which particle is the removal of an electron the most difficult?

A $Cl^-(g)$ **B** $F^-(g)$ **C** $K^+(g)$ **D** $Na^+(g)$

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

560 kg of nitrogen and 120 kg of hydrogen are pressurised, heated and passed over an iron catalyst. When the mixture of gases reaches equilibrium, it contains 96 kg of hydrogen.

Which mass of ammonia does it contain?

A 24 kg **B** 68 kg **C** 136 kg **D** 680 kg

© UCLES 2011

5 The presence of dipoles helps to explain why the element Br_2 and the compound $CHCl_3$ exist as liquids at room temperature.

Which types of dipole are involved?

	Br_2	$CHCl_3$
A	induced dipoles and permanent dipoles	induced dipoles and permanent dipoles
B	induced dipoles and permanent dipoles	induced dipoles only
C	induced dipoles only	induced dipoles and permanent dipoles
D	induced dipoles only	induced dipoles only

6 Three compounds have the physical properties shown in the table.

compound	**P**	**Q**	**R**
melting point / °C	2852	993	–119
boiling point / °C	3600	1695	39
conductivity (solid)	poor	poor	poor
conductivity (liquid)	good	good	poor
conductivity (aqueous)	insoluble	good	insoluble

What might be the identities of **P**, **Q** and **R**?

	P	**Q**	**R**
A	MgO	KCl	NH_3
B	MgO	NaF	C_2H_5Br
C	SiO_2	KCl	C_2H_5Br
D	SiO_2	NaF	HCl

7 For the equilibrium $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what will change the value of K_p?

A adding a catalyst

B adding more O_2

C increasing the pressure

D increasing the temperature

8 Which pollutant, present in the exhaust fumes of an internal combustion engine, has an element in the +2 oxidation state and an odd number of electrons in one molecule of the pollutant?

A CO **B** H_2S **C** NO **D** NO_2

© UCLES 2011

9 The use of sucrose in food processing depends in part on osmotic pressure, symbol Π.

In dilute solution, Π varies with concentration in a similar way to gas behaviour. The equation $\Pi V = nRT$ can be used, where n is the number of moles of solute molecules contained in volume V at temperature T. The number of moles of solvent molecules should be ignored.

Under aqueous acidic conditions sucrose is hydrolysed.

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{glucose}}{CH_2OH(CHOH)_4CHO} + \underset{\text{fructose}}{CH_2OH(CHOH)_3COCH_2OH}$$

What can be deduced from this hydrolysis equation?

	the osmotic pressure	glucose and fructose are
A	decreases	optical isomers
B	decreases	structural isomers
C	increases	optical isomers
D	increases	structural isomers

10 Hess's Law can be used to calculate the average C-H bond energy in methane.

$\Delta H^{\ominus}_{at}$ = standard enthalpy change of atomisation

$\Delta H^{\ominus}_{f}$ = standard enthalpy change of formation

$\Delta H^{\ominus}_{c}$ = standard enthalpy change of combustion

Which data values are needed in order to perform the calculation?

A $\Delta H^{\ominus}_{at}$ (C), $\Delta H^{\ominus}_{at}$ (H), $\Delta H^{\ominus}_{f}$ (CH_4)

B $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{c}$ (CH_4)

C $\Delta H^{\ominus}_{c}$ (C), $\Delta H^{\ominus}_{c}$ (H_2), $\Delta H^{\ominus}_{f}$ (CH_4)

D $\Delta H^{\ominus}_{f}$ (CH_4) only, as $\Delta H^{\ominus}_{f}$ (C), and $\Delta H^{\ominus}_{f}$ (H_2), are defined as zero

11 The amount of titanium dioxide in an ore can be determined by using the following reaction.

$$3TiO_2 + 4BrF_3 \rightarrow 3TiF_4 + 2Br_2 + 3O_2$$

Which element increases in oxidation number in this reaction?

A bromine

B fluorine

C oxygen

D titanium

© UCLES 2011

12 For the reaction

$$W(aq) + 2X(aq) \rightleftharpoons 2Y(aq) + 3Z(aq)$$

what are the correct units for the equilibrium constant K_c?

A $mol\,dm^{-3}$ **B** $mol^2\,dm^{-6}$ **C** $mol^{-1}\,dm^3$ **D** $mol^{-2}\,dm^6$

13 Methyl mercaptan, CH_3SH, has a foul smell and is often used to impart a smell to natural gas.

What will be formed when CH_3SH is burned in an excess of air?

A CO H_2O SO_2

B CO_2 H_2O H_2S

C CO_2 H_2O SO_2

D CO_2 H_2O SO_3

14 Nitrogenous fertilisers are used extensively in modern farming. If rainwater washes excess fertiliser into a nearby lake, a process called eutrophication may occur.

Three of the stages of eutrophication are described below.

P Water plants growing on the lake bed die due to lack of sunlight.

Q An excessive growth of algae occurs.

R Excessive bacterial activity causes a reduction in oxygen levels.

In which order do these three stages occur?

A P → Q → R

B P → R → Q

C Q → P → R

D Q → R → P

15 Chlorine can be manufactured from brine in a diaphragm cell.

Which row represents the correct electrodes?

	nature of anode	nature of cathode
A	graphite	titanium
B	steel	titanium
C	titanium	graphite
D	titanium	steel

16 Sodium iodide reacts with concentrated sulfuric acid. The equation which represents one of the reactions that takes place is shown.

$$8NaI + 9H_2SO_4 \rightarrow 8NaHSO_4 + 4I_2 + H_2S + 4H_2O$$

Which species has been oxidised in this reaction?

A H^+ **B** I^- **C** Na^+ **D** SO_4^{2-}

17 The standard enthalpy changes of formation of HC*l* and HI are –92 kJ mol^{-1} and +26 kJ mol^{-1} respectively.

Which statement is **most** important in explaining this difference?

A Chlorine is more electronegative than iodine.

B The activation energy for the $H_2 + Cl_2$ reaction is much less than that for the $H_2 + I_2$ reaction.

C The bond energy of HI is smaller than the bond energy of HC*l*.

D The bond energy of I_2 is smaller than the bond energy of Cl_2.

18 Lime mortar is made from quicklime, water and sand. Over a period of time, lime mortar changes into a much harder form. Both fresh and old lime mortar react with aqueous hydrochloric acid but only the old lime mortar effervesces during the reaction.

Which equation describes the change from fresh to old lime mortar?

A $CaO + CO_2 \rightarrow CaCO_3$

B $CaO + H_2O \rightarrow Ca(OH)_2$

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

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

19 Ar, Ca^{2+} and K^+, contain the same number of electrons.

In which order do their radii increase?

	smallest radius ⟶		largest radius
A	Ar	K^+	Ca^{2+}
B	Ca^{2+}	Ar	K^+
C	Ca^{2+}	K^+	Ar
D	K^+	Ar	Ca^{2+}

© UCLES 2011

20 Bromine and propene undergo an addition reaction.

Which is a property of the product?

A It exists in *cis-trans* isomers.

B It is more volatile than propene.

C It possesses a chiral centre.

D It possesses hydrogen bonding.

21 Buta-1,3-diene is currently obtained from fossil fuel sources. In future it may be obtained from ethanol, which can be produced from non-food agricultural crops. The sequence of reactions is as follows.

$$CH_3CH_2OH \xrightarrow{\text{step 1}} CH_3CHO \xrightarrow{\text{step 2}} CH_3CH(OH)CH_2CHO \xrightarrow{\text{step 3}} CH_2{=}CHCH{=}CH_2$$

buta-1,3-diene

Which term could be used to describe step 1?

A condensation

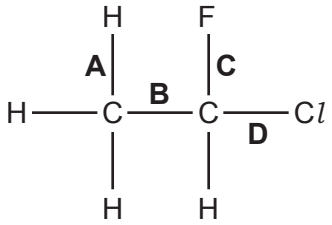
B dehydration

C dehydrogenation

D hydrogenation

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

Which bond in the structure below has the lowest bond energy?



23 Ethanal, CH_3CHO, can be reduced using $NaBH_4$ in aqueous ethanol.

This is a nucleophilic addition reaction.

What could be the first step of this mechanism?

A attack of an H^- ion at the carbon atom of the carbonyl group

B attack of an H^- ion at the oxygen atom of the carbonyl group

C attack of an H^+ ion at the carbon atom of the carbonyl group

D attack of an H^+ ion at the oxygen atom of the carbonyl group

24 In a sequence of reactions, ethanal is converted into a compound **H**.

$$CH_3CHO \xrightarrow{HCN,\ NaCN} \mathbf{F} \xrightarrow{\text{hot dilute } H_2SO_4} \mathbf{G} \xrightarrow[\text{trace of conc. } H_2SO_4]{CH_3OH,\ \text{heat}} \mathbf{H}$$

What could **H** be?

A $CH_3CH_2COOCH_3$

B $CH_3CH(OH)COOCH_3$

C $CH_3CH(OH)OCOCH_3$

D $CH_3CH(OCH_3)COOH$

25 What is involved in the mechanism of the reaction between aqueous sodium hydroxide and 2-bromo-2-methylbutane?

A heterolytic bond fission, attack by an electrophile on a carbanion

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

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

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

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

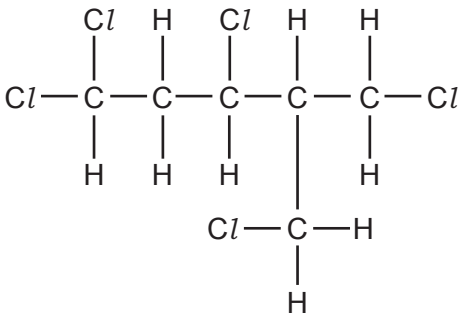
2.30 g of ethanol were mixed with aqueous acidified potassium dichromate(VI). The desired product was collected by immediate distillation under gentle warming.

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** 3.14 g

27 The molecule shown is optically active.



How many chiral carbon atoms are present in this molecule?

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

© UCLES 2011

28 Which reagent could best be used to distinguish between cyclohexene and cyclohexanol?

A $Ag(NH_3)_2^+$ in H_2O

B Br_2 in CCl_4

C 2,4-dinitrophenylhydrazine in CH_3OH

D $NaBH_4$ in CH_3OH

29 Compound X, molecular formula C_4H_8, undergoes the following reactions.

$$\underset{\textbf{X}}{C_4H_8} \xrightarrow{Br_2} \underset{\textbf{Y}}{C_4H_8Br_2} \xrightarrow{\text{aq.NaOH / heat}} \underset{\textbf{Z}}{C_4H_{10}O_2}$$

$$\underset{\textbf{X}}{C_4H_8} \xrightarrow{H_2 / Ni} \text{methylpropane}$$

What is the formula of compound Z?

A $CH_3CH_2CH(OH)CH_2OH$

B $CH_3CH(OH)CH(OH)CH_3$

C $CH_3CH(CH_2OH)CH_2OH$

D $(CH_3)_2C(OH)CH_2OH$

30 How many of the isomeric alcohols with the formula C_4H_9OH will produce an alkene that has cis and trans isomers, on treatment with conc. H_2SO_4?

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

© UCLES 2011

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.

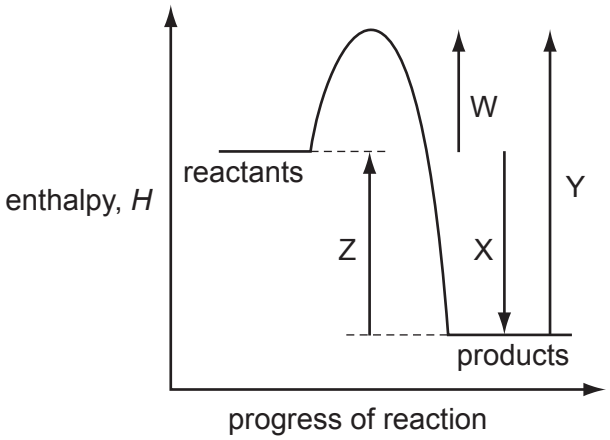
31 Which statements about bond angles are correct?

1 The bond angle in SO_2 is smaller than the bond angle in CO_2.

2 The bond angle in H_2O is smaller than the bond angle in CH_4.

3 The bond angle in NH_3 is smaller than the bond angle in BF_3.

32 An energy profile diagram is shown.



What do the labels on the diagram represent?

1 W = ΔH of the forward reaction, Y = E_a of the backward reaction

2 Z = ΔH of the backward reaction, Y = E_a of the backward reaction

3 X = ΔH of the forward reaction, W = E_a of the forward reaction

© UCLES 2011

33 Which are assumptions of the kinetic theory of gases and hence of the ideal gas equation, $PV = nRT$?

1 Molecules move without interacting with one another except for collisions.

2 Intermolecular forces are negligible.

3 Intermolecular distances are much greater than the molecular size.

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

Which properties would be expected for radium, $_{88}Ra$, or its compounds?

1 Radium carbonate would not decompose at the temperature of a Bunsen flame.

2 Radium hydroxide is very insoluble.

3 Radium does not react with cold water.

35 When a firework is lit, a fuel and an oxidising agent react together.

In one such firework, magnesium is the fuel and barium nitrate is the oxidising agent.

Which solids are produced when the firework is lit?

1 BaO

2 MgO

3 $Mg(NO_3)_2$

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 The oxidation number of ***X*** increases by 2 from ***Y*** to ***Z***.

2 The molecule of ***Y*** has no unpaired electrons.

3 The molecule of ***Z*** contains three oxygen atoms.

© UCLES 2011

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.

37 Compound **X** has molecular formula $C_4H_{10}O$. Separate samples of **X** are tested with three different reagents.

Which results could **not** be obtained?

	Tollens' reagent	2,4-dinitrophenylhydrazine reagent	warm acidified potassium dichromate(VI) solution
1	silver mirror forms	orange precipitate forms	colour changes from orange to green
2	no change	no change	no change
3	no change	no change	colour changes from orange to green

38 **Y** is an organic compound. **Y** gives a precipitate with aqueous silver nitrate. All of this precipitate dissolves when concentrated aqueous ammonia is added.

What is a possible identity for **Y**?

1 1-bromopropane

2 chloroethane

3 2-iodo-2-methylpropane

39 Which compounds will produce ethanoic acid when boiled under reflux with dilute alkali followed by acidification?

1 CH_3CH_2Cl

2 $CH_3CO_2CH_3$

3 CH_3CN

© UCLES 2011

40 Which pairs of homologous series have the same C:H ratio in their general formulae?

1 aldehydes and ketones

2 carboxylic acids and esters

3 alkenes and ketones

© UCLES 2011

BLANK PAGE

BLANK PAGE

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

University of Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© UCLES 2011