Higher Chemistry Paper I Specimen Question Paper

Check that the answer sheet provided is for Higher Chemistry Paper I.
Fill in the details required on the answer sheet.
Reference may be made to the Chemistry Higher and Advanced Higher Data Booklet (1999 edition). [This will be provided October/November 1998.]
Rough working, if required, should be done only on this question paper, or on the rough working sheet provided—not on the answer sheet.
Instructions for the completion of Part 1 and Part 2 are given on pages two and eight respectively.
PART 1

In questions 1 to 30 of this part of the paper, an answer is given by indicating the choice A, B, C or D by a stroke made in INK in the appropriate place in Part 1 of the answer sheet—see the sample question below.

For each question there is only ONE correct answer.

This part of the paper is worth 30 marks.

SAMPLE QUESTION

To show that the ink in a ball-pen consists of a mixture of dyes, the method of separation would be

A fractional distillation
B chromatography
C fractional crystallisation
D filtration.

The correct answer is B—chromatography. A heavy vertical line should be drawn joining the two dots in the appropriate box in the column headed B as shown in the example on the answer sheet.

If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:

If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:

Page two
1. In which of the following structures would the nails corrode before the roof itself?
   A Zinc roof with iron nails
   B Iron roof with copper nails
   C Zinc roof with copper nails
   D Copper roof with iron nails

2. Different isotopes of the same element have identical
   A nuclei
   B electron arrangements
   C numbers of neutrons
   D mass numbers.

3. A mixture of magnesium bromide and magnesium sulphate is known to contain 3 mol of magnesium and 4 mol of bromide ions.
   How many moles of sulphate ions are present?
   A 1
   B 2
   C 3
   D 4

4. The graph below shows the variation of concentration of a reactant with time as a reaction proceeds.

   The average reaction rate, in mol l\(^{-1}\) s\(^{-1}\), during the first 20 s is
   A 0.0025
   B 0.0036
   C 0.0075
   D 0.0090.

5. The graph shows the distribution of kinetic energies of the molecules in a sample of gas.

   Which graph would show the kinetic energies of the molecules when the sample is cooled by 10 °C?

   A
   B
   C
   D

6. A student found that 310 kJ of energy was released on burning 10 g of propan-1-ol, CH\(_3\)CH\(_2\)CH\(_2\)OH.
   From this experiment, what is the enthalpy of combustion, in kJ mol\(^{-1}\), of propan-1-ol?
   A −310
   B −1296
   C −1860
   D −3100
7. Silicon carbide can be used as
   A  a lubricant
   B  a tip for cutting/grinding tools
   C  a substitute for pencil “lead”
   D  an electrical conductor.

8. What is the amount of oxygen atoms in 0.5 mol of carbon dioxide?
   A  0.25 mol
   B  0.5 mol
   C  1 mol
   D  2 mol

9. \( \text{N}_2(g) + 2\text{O}_2(g) \rightarrow 2\text{NO}_2(g) \)
   How many litres of nitrogen dioxide gas could theoretically be obtained by sparking 4 litres of nitrogen gas with excess of oxygen gas?
   (All volumes are measured under the same conditions of temperature and pressure.)
   A  2
   B  4
   C  6
   D  8

10. Which of the following contains approximately \( 3 \times 10^{23} \) molecules?
    A  17 g \( \text{NH}_3 \)
    B  36 g \( \text{H}_2\text{O} \)
    C  4 g \( \text{CH}_4 \)
    D  22 g \( \text{CO}_2 \)

11. Which reaction is an example of a reaction which takes place during reforming?

   A  \( \text{CH}_3 \rightarrow \text{CH}_2 \rightarrow \text{CH}_2 \rightarrow \text{CH}_3 \rightarrow \text{CH}_3 \rightarrow \text{CH}_2 \rightarrow \text{CH}_3 \rightarrow \text{CH}_2 = \text{CH}_2 \)

   B  \( \text{CH}_3 \rightarrow \text{CH}_2 \rightarrow \text{CH}_2 \rightarrow \text{CH}_2 \rightarrow \text{CH}_3 \rightarrow \text{CH}_3 \rightarrow \text{CH}_3 \rightarrow \text{CH}_2 = \text{CH}_2 \)

   C  \( \text{CH}_3 \rightarrow \text{CH}_3 \rightarrow \text{CH}_2 \rightarrow \text{CH}_2 = \text{CH}_2 \rightarrow \text{H}_2 \)

   D  \( n \text{CH}_2 = \text{CH}_2 \rightarrow (\text{CH}_2 = \text{CH}_2)_n \rightarrow \)
12. A compound used in the synthesis of thermosetting plastics is:

\[ \text{H} \quad \text{H} \]
\[ \text{C} \quad \text{O} \]

The name of this compound is
A methanol
B methanal
C methanoic acid
D methanone.

13. Which of the alcohols can be oxidised to give a ketone?
A 2-methylbutan-1-ol
B 2, 3-dimethylpentan-1-ol
C 3-methylbutan-2-ol
D 2-methylbutan-2-ol

14. Which kind of reaction is used to produce an ester from a carboxylic acid and an alcohol?
A Addition
B Condensation
C Hydration
D Hydrolysis

15. The dehydration of butan-2-ol can produce two isomeric alkenes, but-1-ene and but-2-ene.
Predict which alkanol can similarly produce, on dehydration, a pair of isomeric alkenes.
A propan-2-ol
B pentan-3-ol
C hexan-3-ol
D heptan-4-ol

16. Destroying ozone may have serious consequences.
Which statement about ozone is untrue?
A It absorbs ultraviolet radiation.
B It has the formula O₃.
C It is classified as a CFC.
D It can react with halogenoalkanes.

17. A part of the formula for nylon is shown.

\[ \text{H} \quad \text{H} \quad \text{O} \quad \text{O} \]
\[ \text{N} \quad (\text{CH₂})₆ \quad \text{N} \quad \text{C} \quad (\text{CH₂})₄ \quad \text{C} \]

This polymer is classed as a
A synthetic addition polymer
B synthetic condensation polymer
C natural condensation polymer
D natural addition polymer.

18. Polyester fibres and cured polyester are both very strong.
Which kinds of structure do their molecules have?

<table>
<thead>
<tr>
<th>Fibre</th>
<th>Cured resin</th>
</tr>
</thead>
<tbody>
<tr>
<td>A three-dimensional</td>
<td>three-dimensional</td>
</tr>
<tr>
<td>B linear</td>
<td>linear</td>
</tr>
<tr>
<td>C three-dimensional</td>
<td>linear</td>
</tr>
<tr>
<td>D linear</td>
<td>three-dimensional</td>
</tr>
</tbody>
</table>

Page five
19. Part of a polyester chain is shown below.

\[ O \quad O \quad C \quad (CH_2)_4 \quad C \quad O \quad (CH_2)_4 \quad O \quad C \quad (CH_2)_4 \quad C \quad O \quad (CH_2)_4 \quad O \]

Which compound, when added to the reactants during polymerisation, would stop the polyester chain from getting too long?

A

\[ HO \quad C \quad (CH_2)_4 \quad C \quad OH \]

B

\[ HO \quad (CH_2)_4 \quad OH \]

C

\[ HO \quad (CH_2)_4 \quad C \quad OH \]

D

\[ CH_3 \quad OH \]

20. Which process is represented by the following equation?

\[ CH_2 \quad O \quad C \quad CH_{17}H_{35} \quad OH \quad CH_2 \quad OH \]

\[ CH \quad O \quad C \quad CH_{17}H_{35} \quad + \quad 3H_2O \quad CH \quad OH \quad + \quad 3CH_{17}H_{35}COOH \]

A Condensation
B Hydrolysis
C Oxidation
D Dehydration

21. Which of the following must contain nitrogen?

A A protein
B An oil
C A polyester
D A carbohydrate

22. Which of the following is not a raw material in the chemical industry?

A Air
B Ethene
C Methane
D Water
23. The enthalpies of combustion of C(s), H₂(g) and C₄H₉OH(ℓ), butan-1-ol, in kJ mol⁻¹, are as follows.

\[
\begin{align*}
\text{C(s)} + \text{O}_2(g) & \rightarrow \text{CO}_2(g) \quad \Delta H = a \\
\text{H}_2(g) + \frac{1}{2}\text{O}_2(g) & \rightarrow \text{H}_2\text{O}(ℓ) \quad \Delta H = b \\
\text{C}_4\text{H}_9\text{OH}(ℓ) + 6\text{O}_2(g) & \rightarrow 4\text{CO}_2(g) + 5\text{H}_2\text{O}(ℓ) \quad \Delta H = c
\end{align*}
\]

The enthalpy of formation of butan-1-ol is given by the equation:

\[
4\text{C(s)} + 5\text{H}_2(g) + \frac{3}{2}\text{O}_2(g) \rightarrow \text{C}_4\text{H}_9\text{OH}(ℓ)
\]

Which of the following can be used to calculate the enthalpy of formation of butan-1-ol?

A. 4a + 5b - c
B. 2a + 10b - c
C. c - 4a - 5b
D. 2a + 5b + c

24. In which of the reactions will the equilibrium be unaffected by a change in pressure?

A. 2\text{NO}(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}_2(g)
B. 2\text{NO}_2(g) \rightleftharpoons \text{N}_2\text{O}_4(g)
C. \text{H}_2(g) + \text{I}_2(g) \rightleftharpoons 2\text{HI}(g)
D. \text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g)

25. \text{Cl}_2(g) + \text{H}_2\text{O}(ℓ) \rightleftharpoons \text{Cl}^-\text{(aq)} + \text{ClO}^-\text{(aq)} + 2\text{H}^+(\text{aq})

Which substance would move the above equilibrium to the right?

A. Hydrogen chloride
B. Sodium bromide
C. Chlorine
D. Hydrogen

26. The following acid solutions all have a concentration of 0.1 mol L⁻¹.

In which solution would the concentration of \text{H}^+(\text{aq}) ions be less than 0.1 mol L⁻¹?

A. Ethanoic acid
B. Hydrochloric acid
C. Nitric acid
D. Sulphuric acid

27. A fully dissociated acid is diluted by the addition of water.

Which of the following would increase with increasing dilution?

A. The pH value
B. The electrical conductivity
C. The rate of its reaction with chalk
D. The volume of alkali which it will neutralise

28. During a redox process in acid solution, iodate ions, \text{IO}_3^-(\text{aq}), are converted into iodine, \text{I}_2(\text{aq}).

\[
2 \text{IO}_3^-(\text{aq}) \rightarrow \text{I}_2(\text{aq})
\]

The numbers of \text{H}^+(\text{aq}) and \text{H}_2\text{O}(ℓ) required to balance the ion-electron equation for the formation of 1 mol of \text{I}_2(\text{aq}) are, respectively

A. 6 and 3
B. 3 and 6
C. 12 and 6
D. 6 and 12.

29. Which of the following has an electrical charge?

A. \text{α}-particles
B. X-rays
C. Neutrons
D. \text{γ}-rays

30. The chart below was obtained from an 8-day old sample of an \text{α}-emitting radioisotope.

![Abundance chart]

What is the half-life of the radioisotope?

A. 2 days
B. 4 days
C. 8 days
D. 12 days
PART 2

In questions 31 to 34 of this part of the paper, an answer is given by circling the appropriate letter (or letters) in the answer grids provided on Part 2 of the answer sheet.

In some questions, two letters are required for full marks.

If more than the correct number of answers is given, marks may be deducted.

In some cases the number of correct responses is NOT identified in the question.

This part of the paper is worth 10 marks.

SAMPLE QUESTION

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
</tbody>
</table>

(a) Identify the diatomic compound(s).

The one correct answer to part (a) is D. This should be circled.

(b) Identify the two substances which burn to produce both carbon dioxide and water.

As indicated in this question, there are two correct answers to part (b). These are A and E. Both answers are circled.

(c) Identify the substance(s) which can not be used as a fuel.

There are two correct answers to part (c). These are C and F. Both answers are circled.

If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and circle the answer you now consider to be correct. Thus, in part (a), if you want to change an answer D to an answer A, your answer sheet would look like this:

If you want to change back to an answer which has already been scored out, you should enter a tick (✓) in the box of the answer of your choice, thus:

Page eight
31. The results of three reactions are plotted on the graph.

Curve I shows the results for the reaction of excess zinc with $100 \text{ cm}^3$ of $0.2 \text{ mol l}^{-1}$ sulphuric acid.

(a) Identify the two chemicals which would react to give the results shown by curve II.
(b) Identify the two chemicals which would react to give the results shown by curve III.

32. The first twenty elements in the Periodic Table can be categorised according to their bonding and structure.

(a) Identify the element which exists as a covalent network solid.
(b) Identify the element which exists as a discrete covalent molecular solid.
(c) Identify the most electronegative element.
Many organic compounds contain oxygen.

(a) Identify the compound which is an isomer of the compound shown in box A.

(b) Identify the compound(s) which could be oxidised to form the compound shown in box E.

34. Read the following passage from a popular scientific journal. It discusses the nuclear reactions which occur during the explosion of a star.

“Stars produce heavier elements when they explode as supernovae . . . The main product (of the supernova) should be radioactive nickel. It forms (from) nuclei of oxygen. Heat from a shock wave ‘welds’ the oxygen into heavier nuclei. This radioactive nickel decays into cobalt, which in turn decays into iron.”

(from New Scientist, 11 August 1988)

Identify the reaction(s) which can be found in the passage.

A | Nuclear fission | B | Nuclear fusion
---|---|---|---
C | Loss of an alpha particle | D | Loss of a beta particle
E | Loss of a proton | F | Loss of a neutron

[END OF QUESTION PAPER]
### Higher Chemistry Paper I

#### Marking Instructions

(1) - for each correct response

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>D</td>
<td>11</td>
<td>B</td>
<td>21</td>
<td>A</td>
<td>31</td>
<td>a B E</td>
</tr>
<tr>
<td>2</td>
<td>B</td>
<td>12</td>
<td>B</td>
<td>22</td>
<td>B</td>
<td>b</td>
<td>C D</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
<td>13</td>
<td>C</td>
<td>23</td>
<td>A</td>
<td>32</td>
<td>a A</td>
</tr>
<tr>
<td>4</td>
<td>C</td>
<td>14</td>
<td>B</td>
<td>24</td>
<td>C</td>
<td>b</td>
<td>E</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>15</td>
<td>C</td>
<td>25</td>
<td>C</td>
<td>c</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
<td>16</td>
<td>C</td>
<td>26</td>
<td>A</td>
<td>33</td>
<td>a D</td>
</tr>
<tr>
<td>7</td>
<td>B</td>
<td>17</td>
<td>B</td>
<td>27</td>
<td>A</td>
<td>b</td>
<td>A B</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>18</td>
<td>D</td>
<td>28</td>
<td>C</td>
<td>34</td>
<td>B E</td>
</tr>
<tr>
<td>9</td>
<td>D</td>
<td>19</td>
<td>D</td>
<td>29</td>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>D</td>
<td>20</td>
<td>B</td>
<td>30</td>
<td>B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fill in these boxes and read what is printed below.

Full name of school or college  

Town

First name and initials  

Surname

Date of birth  

Day  

Month  

Year  

Candidate number

Number of seat

All questions should be attempted.

Necessary data will be found in the Chemistry Higher and Advanced Higher Data Booklet (1999 Edition). [This will be provided October/November 1998.]

The questions may be answered in any order but all answers are to be written in this answer book, and must be written clearly and legibly in ink.

Rough work, if any should be necessary, as well as the fair copy, is to be written in this book.

Rough work should be scored through when the fair copy has been written.

Additional space for answers and rough work will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the invigilator and should be inserted inside the front cover of this booklet.

The size of the space provided for an answer should not be taken as an indication of how much to write. It is not necessary to use all the space.

Before leaving the examination room, you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.
1. Both hydrogen and methanol have been considered as alternative fuels to petrol for use in cars.

   (a) (i) State one advantage in using hydrogen as a fuel instead of petrol.

   (ii) State one disadvantage of using methanol as a fuel instead of petrol.

(b) Methanol can be prepared in the following way.

```
methane → steam reforming → X → conversion → methanol
```

Identify X.
2. Diamond and graphite are well known forms of the element carbon. Other forms of pure carbon have been
made. They exist as individual molecules of different sizes and are called fullerenes. The main fullerene
has the formula $C_{60}$.

(a) How does the structure of a fullerene differ from that of diamond?

(b) Fullerenes were first made by passing a high current of electricity through a graphite rod in an
atmosphere of helium. This caused the graphite to vaporise.
Why was an atmosphere of helium used for producing fullerenes?

(c) Fullerenes can be made into hydrocarbons. One such hydrocarbon has the formula $C_{60}H_{36}$.
Describe a chemical test which could be carried out on a solution of $C_{60}H_{36}$ to show whether the
hydrocarbon is saturated or unsaturated.
3. Ammonia is now one of the world’s most important chemicals, about two million tonnes being produced each year in the UK alone.

It is manufactured by the direct combination of nitrogen and hydrogen by the Haber Process.

\[
\text{N}_2(g) + 3\text{H}_2(g) \rightleftharpoons 2\text{NH}_3(g) \quad \Delta H = -92 \text{ kJ mol}^{-1}
\]

The Haber Process is operated as a continuous process, and the reaction is never allowed to reach equilibrium.

(a) (i) What does the term “equilibrium” mean, when applied to a chemical reaction?

(ii) Why is the Haber Process not carried out at a very high temperature?

(b) State one advantage of operating the Haber Process as a continuous process.
4. The apparatus below was used by a student to find the enthalpies of combustion of alcohols.

(a) Write down the measurements the student should take.

(b) The enthalpies of combustion of three alcohols are shown in the table.

<table>
<thead>
<tr>
<th>Alcohol</th>
<th>Enthalpy of combustion/kJ mol(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>methanol</td>
<td>-715</td>
</tr>
<tr>
<td>ethanol</td>
<td>-1371</td>
</tr>
<tr>
<td>propanol</td>
<td>-2010</td>
</tr>
</tbody>
</table>

Why is there a **regular** stepwise increase in the enthalpies of combustion from methanol to ethanol to propanol?
5. A group of students designed the following apparatus to compare the viscosities of different liquids.

(a) Suggest how the apparatus could be used to compare the viscosities of different liquids.

(b) The viscosities of many liquids are affected by hydrogen bonding. Explain what is meant by hydrogen bonding.
6. The following triglyceride is found in some fats and oils.

\[
\begin{align*}
\text{H}_2\text{C} - \text{O} - \text{C} - \text{(CH}_2\text{)}_{16}\text{CH}_3 \\
\text{H} - \text{O} - \text{C} - \text{(CH}_2\text{)}_7\text{CH} - \text{(CH}_2\text{)}_7\text{CH}_3 \\
\text{H}_2\text{C} - \text{O} - \text{C} - \text{(CH}_2\text{)}_{16}\text{CH}_3
\end{align*}
\]

(a) The hydrolysis of the triglyceride produces an alcohol and long chain fatty acids.

(i) Name the alcohol produced by the hydrolysis of the triglyceride.

(ii) Suggest why the sequence of fatty acids in the triglyceride can be referred to as S, O, S.

(You may wish to refer to the data booklet.)

(b) What happens to triglyceride molecules in the conversion of oils to hardened fats?
7. Urea is a substance found in human urine. The enzyme urease catalyses the hydrolysis of urea.

\[
\text{CO(NH}_2\text{)}_2 + \text{H}_2\text{O} \xrightarrow{\text{urease enzyme}} \text{CO}_2 + 2\text{NH}_3
\]

The concentration of urea in a sample can be estimated using an indicator as shown in the diagram.

The bromothymol blue indicator is yellow below pH 6 and blue above pH 8.3.

(a) Draw the full structural formula for urea.

(b) The initial yellow colour of the indicator changed to blue as the experiment proceeded. Explain fully the colours observed.
7. (continued)

(c) The pH of the gel after one completed experiment was found to be 11. Calculate the concentration of hydroxide ions, in mol l\(^{-1}\).

(d) The graph shows the potential energy diagram for a urease catalysis of urea.

(i) What is the enthalpy change for the reaction, in kJ mol\(^{-1}\)?

(ii) Acid is a less effective catalyst than urease for this reaction. Add a curve to the potential energy diagram to show the hydrolysis when acid is used as the catalyst.
8. Esters are important compounds which have many applications.

(a) Some of the instructions outlining the laboratory preparation of an ester are shown below.

**Preparation of an Ester**

1. Mix 1 cm$^3$ of the alkanol with 1 cm$^3$ of the alkanoic acid in a test tube.

2.

3.

4. After 20 minutes, pour the contents of the test tube into a beaker containing sodium hydrogen carbonate solution.

Add appropriate instructions for steps 2 and 3.

(b) The full structural formula for an ester is shown below.

```
H   H   O   H   H   H
|   |   |   |   |   |
H — C — C — C — C — O — C — C — C — H
|   |   |   |   |   |
H   H   H   H   H
```

Give the systematic name of the alkanol used in making this ester.

(c) State a use of esters.
In 1926, Hinshelwood and Green studied the reaction between nitric oxide and hydrogen at temperatures above 150 °C.

The equation for the reaction is:

\[
2\text{NO}(g) + 2\text{H}_2(g) \rightarrow \text{N}_2(g) + 2\text{H}_2\text{O}(g)
\]

A simplified diagram of their apparatus is shown below.

(a) Predict what will happen to the mercury levels as the reaction proceeds.

(b) The use of narrow glass tubing ensured that only a small volume of gas was outwith the reaction vessel.

Suggest why this precaution was taken.

(c) Calculate the mass of nitrogen obtained under these conditions when 500 cm\(^3\) of nitric oxide reacted completely with hydrogen.

(Take the molar volume of nitrogen to be 25.0 litres mol\(^{-1}\).)

(Show your working clearly.)
10. The boiling points of three halogens are shown in the table.

<table>
<thead>
<tr>
<th>Halogen</th>
<th>Boiling point/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>chlorine</td>
<td>-35</td>
</tr>
<tr>
<td>bromine</td>
<td>59</td>
</tr>
<tr>
<td>iodine</td>
<td>184</td>
</tr>
</tbody>
</table>

(a) Explain why the boiling points of the halogens increase down the group.

(b) (i) The graph shows the first ionisation energies of successive elements with increasing atomic number.

Elements A and B belong to the same group of the Periodic Table. Identify the group.

(ii) Calculate the energy change for the process:

\[ \text{Al}(g) \rightarrow \text{Al}^{3+}(g) + 3e^- \]
11. The enthalpy of lattice breaking for rubidium chloride is the enthalpy change for the following process.

\[
\text{RbCl}(s) \rightarrow \text{Rb}^+(g) + \text{Cl}^-(g)
\]

This enthalpy change can be calculated using the enthalpy changes in the table below.

<table>
<thead>
<tr>
<th>Enthalpy change</th>
<th>( \Delta H/\text{kJ mol}^{-1} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( \text{RbCl}(s) \rightarrow \text{Rb}^+(aq) + \text{Cl}^-(aq) )</td>
<td>+17</td>
</tr>
<tr>
<td>2 ( \text{Rb}^+(g) \rightarrow \text{Rb}^+(aq) )</td>
<td>+301</td>
</tr>
<tr>
<td>3 ( \text{Cl}^-(g) \rightarrow \text{Cl}^-(aq) )</td>
<td>+364</td>
</tr>
</tbody>
</table>

(a) Name enthalpy change 1.

(b) Calculate the enthalpy of lattice breaking, in kJ mol\(^{-1}\), for rubidium chloride.

(Show your working clearly.)
12. Part of a workcard is shown.

**WORKCARD**

To find the number of coulombs required to produce one mole of hydrogen by electrolysis of dilute sulphuric acid.

1. Assemble the apparatus as shown. (Do not switch on.)
2. Set the voltage to 6 V D.C.
3. Switch on and adjust the variable resistor to give a current of 0.5 A.
4. Switch off.

(a) (i) What is the next step before switching the current back on again?

(ii) In addition to the current, what measurements should be taken?

(b) A student carrying out this experiment passed the current through the solution for 10 minutes. Calculate the mass of hydrogen produced.

(Show your working clearly.)
13. The following reaction can be readily carried out in the laboratory.

\[ \text{C}_6\text{H}_{12}\text{O} \xrightarrow{\text{alcohol}} \text{C}_6\text{H}_{10}\text{O} \]

(a) Why can this reaction be classified as oxidation?

(b) The alcohol does not react with bromine solution and the product does not react with Benedict’s solution.

Draw a structural formula for the product.
14. About 2.5 million tonnes of sulphuric acid are produced each year in the UK.

(a) Sulphuric acid was made industrially by the Chamber Process. The following chemical reactions are involved.

Sulphur is burned to produce sulphur dioxide.
Sulphur dioxide reacts with water to produce sulphurous acid.
Nitric oxide is produced by the catalytic oxidation of ammonia; water is also a product of this reaction.
Nitric oxide reacts with oxygen to form nitrogen dioxide.
Nitrogen dioxide reacts with sulphurous acid to form sulphuric acid and regenerate nitric oxide.

Complete the flow diagram of the Chamber Process with the names of the chemicals involved in the reactions.
14. (continued)

(b) Sulphuric acid is used in the manufacture of fertilisers.

(i) Write a balanced equation showing the formation of ammonium sulphate from ammonia and sulphuric acid.

(ii) Explain why ammonium sulphate dissolves in water to form an acidic solution.
15. Part of a polymer structure is shown below.

\[ \begin{align*} 
&\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\
&\text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \quad \text{C} \\
&\text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H}
\end{align*} \]

(a) Draw the structure for the monomer from which it is made.

(b) This polymer can be treated to make a polymer which conducts electricity. Why does it conduct electricity?
16. Addition of hydrogen chloride to an alkene can give two products. Markovnikoff observed that the hydrogen of the hydrogen chloride mainly attaches to the carbon atom of the double bond which already has the most hydrogens directly attached to it.

(a) Draw the full structural formula for the major product formed when hydrogen chloride reacts with propene.

(b) Why is it not necessary to consider Markovnikoff’s rule when hydrogen chloride reacts with but-2-ene?
17. The water in swimming pools can be kept sterile by the addition of chlorine which kills microorganisms. The chlorine levels in swimming pool water can be determined by titrating samples against acidified iron(II) sulphate solution. The reaction taking place is:

\[
\text{Cl}_2(aq) + 2\text{Fe}^{2+}(aq) \rightarrow 2\text{Cl}^-(aq) + 2\text{Fe}^{3+}(aq)
\]

(a) Write the ion-electron equation for the oxidation half reaction.

(b) A 100 cm\(^3\) sample of water from a swimming pool required 24.9 cm\(^3\) of 2.82 \(\times\) \(10^{-4}\) mol l\(^{-1}\) iron(II) sulphate solution to reach the end point. Calculate the chlorine concentration, in g l\(^{-1}\), in the swimming pool water. (Show your working clearly.)
SPACE FOR ANSWERS
Higher Chemistry
Paper II
Specimen Marking Instructions
1.

(a) (i) Hydrogen does not produce CO / CO₂ on combustion or hydrogen does not pollute or petrol produces CO / CO₂ on combustion or petrol produces pollutants 1

(ii) Methanol can result in corrosion in the car engine or produces less energy per litre or methanol is toxic 1

(b) X is synthesis gas or a mixture of CO and H₂ 1

**total 3 marks**

2.

(a) or Fullerene comprises discrete (covalent) molecules diamond is a (covalent) network 1

(b) or So that carbon would not react (with anything) so that carbon dioxide would not form or helium is inactive / inert 1

(c) Add the C₆₀H₃₆ to bromine (solution)(water) rapidly decolourised -------> unsaturated 1/2 not/slowly decolourised -------> saturated 1/2

**total 3 marks**
3.

(a) (i) Rate of forward reaction = rate of reverse reaction
or reactants are converted to products at same rate
as products are converted to reactants 1

(ii) The ammonia formed breaks down again
or the equilibrium may be driven to the LHS
or the reverse reaction may be favoured
or the yield of ammonia is low 1

(b) Method is suited to high production
or process is more easily automated
or process is more easily controlled
or low risk of contamination
or quality is consistent
or labour costs are lower
or waste is minimal 1

Total 3 marks

4.

(a) mass (volume) of water 1/2
or initial and final temperature of water
or temperature rise 1/2
or initial and final mass of burner
or mass / weight change of burner 1

(b) Each member of series has 1 more C
and 2 more H’s
or one more CO2 and one more H2O forms
or regular increase arises from the regular increase in
number of bonds being broken and new bonds being
formed 1

total 3 marks
5.

(a) Set the power pack to a fixed voltage  
the higher the rate of rotation,  
the less viscous the liquid  

or

Find the voltage required to maintain a  
certain rate of rotation of the glass  
stirring paddle  
the higher the voltage, the more  
viscous the liquid  

or

Maintain a certain rate of rotation  
the higher the liquid rises,  
the less viscous it is  

(b) Large difference in electronegativity between atoms  
in covalent bonds leads to very polar bonds  
this leads to strong intermolecular forces  

**total 4 marks**

6.

(a) (i) glycerol  
or propane-1,2,3-triol  
or propan-1,2,3-triol  
(Do not penalise missing dashes, commas)  

(ii) SOS refers to the sequence  
stearic, oleic, stearic  

(b) Hydrogen is added to double bonds  
or the molecules become saturated  
or saturation takes place  
or reduction takes place (addition of hydrogen)  

**total 3 marks**
7.

(a) 

\[
\begin{array}{c}
\text{H} \\
\text{N} \\
\text{C} \\
\text{N} \\
\text{H}
\end{array}
\]

Allow \(-\text{NH}_2\) at right hand side and 
\(\text{H}_2\text{N}^-\) at left hand side

do not allow \(-\text{NH}_2\) at left hand side

do not allow other structures such as

\[
\begin{array}{c}
\text{H} \\
\text{H} \\
\text{O} \\
\text{N} \\
\text{N} \\
\text{C} \\
\text{H}
\end{array}
\]

1

(b) Initial yellow colour is due to the 
gel being acidified 
as reaction proceeds ammonia forms 
ammonia is alkaline 
indicator changes colour 

1/2

1/2

1/2

1/2

(c) \(\text{pH} = 11\)

so \([\text{H}^+] = 10^{-11}\) 

so \([\text{OH}^-] = 10^{-14} / 10^{-11} = 10^{-3} \text{ mol}^{-1}\)

1/2

(No penalty for no units 
deduct 1/2 for wrong units)

(d) (i) \(-88 \text{ kJ mol}^{-1}\) (allow \(-86 \text{ to } -90\))

(No penalty for no units 
deduct 1/2 for wrong units)

(ii) curve must commence at 120 \text{ and} \end{at 32 \text{ and} \lie \text{ wholly above} \text{ the given curve.} \)

1

total 6 marks
8.

(a) 2. Add a few drops of (concentrated) sulphuric acid. 1

3. Place in a warm water bath. 1

(b) 2-methylpropan-1-ol 1
or methyl propan-1-ol 1
2 - methylpropanol 1/2

(c) flavouring 1
or in perfumes 1
or in solvents. 1

**total 4 marks**

9.

(a) The mercury will rise in side A or the mercury will fall in side B 1

(b) To ensure that as much of the gas as possible is at the correct temperature or water might condense 1

(c) \[2 \text{NO} + 2\text{H}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O}\]

\[
\begin{align*}
\text{2 mol} & \quad \text{<------>} \quad \text{1 mol} \\
\text{2 vol} & \quad \text{<------>} \quad \text{1 vol} \\
500 \text{ cm}^3 & \quad \text{<------>} \quad 250 \text{ cm}^3 = 0.25 \text{ litre} \quad 1/2 \\
& \quad \quad = 0.25/25 \text{ mol} \quad 1/2 \\
& \quad \quad = 0.01 \text{ mol} \quad 1/2 \\
1 \text{ mol} = 28g & \quad \text{<------>} \quad 0.01 \text{ mol} = 0.28g \quad 1/2
\end{align*}
\]

**total 4 marks**

(Deduct 1/2 for no units or wrong units)
10.

(a) The molecules become larger or heavier therefore Van der Waals' forces are stronger (allow "intermolecular" forces for 1/2) (direction of increase need not be mentioned since it is stated in question) 1

(b) (i) Group 7 1

(ii) $584 + 1830 + 2760 = 5174 \text{ kJ mol}^{-1}$ 1

(Deduct 1/2 for no units or wrong units)

**total 4 marks**

11.

(a) Enthalpy of solution 1

(b) $\text{RbCl(s)} \rightarrow \text{Rb}^+(aq) + \text{Cl}^-(aq) \Delta H = +17$

$\text{Rb}^+(aq) \rightarrow \text{Rb}^+(g) \Delta H = +301 \text{ kJ} \quad 1/2$

$\text{Cl}^-(aq) \rightarrow \text{Cl}^-(g) \Delta H = +364 \text{ kJ} \quad 1/2$

$\text{RbCl(s)} \rightarrow \text{Rb}^+(g) + \text{Cl}^-(g) \Delta H = +682 \text{ kJ mol}^{-1}$

1/2 mark for each correct $\Delta H$ (incl. sign)

1/2 mark for final correct result

(No penalty for no units, deduct 1/2 for wrong units)

**total 3 marks**
12.

(a) (i) Place measuring cylinder in position over negative electrode 1

(ii) Volume of hydrogen collected time during which current was passed 1/2

(b) \[ 2H^+ + 2e \rightarrow H_2 \]

\[
\begin{align*}
2 \text{ mol} & \quad 1 \text{ mol} & \text{1/2} \\
2 \times 96500 \text{ C} & \quad 2\text{g} & \text{1/2} \\
Q = It & \quad \text{1/2} \\
0.5 \times 10 \times 60 & = 300 \text{ Coulombs} & \text{1/2} \\
\text{moles } H_2 & = \frac{300}{193000} & \text{1/2} \\
\text{mass } H_2 & = 2 \times 300 / 193000 & \text{1/2} \\
& = 3.109 \times 10^{-3} \text{ g} & \text{1/2}
\end{align*}
\]

accept 3.1

(Deduct 1/2 for each arithmetical error deduct 1/2 for no / wrong units)

**total 5 marks**

13.

(a) The reaction involves a loss of hydrogen or there is a fall in the hydrogen : oxygen ratio 1

(b) Other isomeric cyclic ketones are acceptable 1

**total 2 marks**
14.
(a) 

or

ammonia

or

oxygen

nitric oxide

water

to show the name of a chemical
to show a reaction

nitrogen dioxide

sulphurous acid

sulphur
doxygen

sulphur

dioxide

water

(b) (i) \[ 2\text{NH}_3 + \text{H}_2\text{SO}_4 \rightarrow (\text{NH}_4)_2\text{SO}_4 \] 
Unbalanced, but all formulae correct 1/2

(ii) \[ \text{NH}_3/\text{NH}_4\text{OH} \text{ is weak} \]
\[ \text{H}_2\text{SO}_4 \text{ is strong} \]
or salt of strong acid / weak base
or \( \text{NH}_4^+ \) combines with OH\(^-\)
\( \text{SO}_4^{2-} \) does not combine with H\(^+\)
or leaving a surplus of H\(^+\)

1/2

1

1

1

1

Total 5 marks
15.

(a) \( \text{H} = \text{C} = \text{C} = \text{H} \) or \( \text{HC} = \text{C} = \text{CH} \) 1

(b) Electrons are free to move across double bonds or electrons in double bonds are delocalised 1

**total 2 marks**

16.

(a) 

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{C} \\
\text{H} \\
\text{Cl} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{C} \\
\text{C} \\
\text{C} \\
\text{H} \\
\text{H} \\
\text{H} \\
\end{array}
\]

allow one missing H but all bonds must be shown. 1

(b) Only one product is possible or the double bond is in the centre of the molecule or the but-2-ene is symmetrical or the two central C atoms are the same 1

**total 2 marks**
17.

(a) \[2\text{Fe}^{2+} \rightarrow 2\text{Fe}^{3+} + 2\text{e}^-\]
or \[\text{Fe}^{2+} \rightarrow \text{Fe}^{3+} + \text{e}^-\]

(b) Moles of iron(II) sulphate solution required
\[= 2.82 \times 10^{-4} \times 24.9 \div 1000\]
\[= 7.021 \times 10^{-6}\]

moles of chlorine = \[7.021 \times 10^{-6} \div 2\]
\[= 3.51 \times 10^{-6}\] present in 100 cm\(^3\) of water.

moles of chlorine present in 1 litre of water
\[= 3.51 \times 10^{-5}\] mol

mass of chlorine present in 1 litre of water
\[= 3.51 \times 10^{-5} \times 71\]
\[= 2.49 \times 10^{-3}\]

(No penalty for no units wrong units deduct 1/2)

**total 4 marks**

[END OF MARKING INSTRUCTIONS]