Cambridge International AS & A Level

CHEMISTRY

9701/11

Paper 1 Multiple Choice

October/November 2020

1 hour

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)
Data booklet

INSTRUCTIONS

• 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 multiple choice answer sheet.
• Follow the instructions on the multiple choice answer sheet.
• Write in soft pencil.
• Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
• Do not use correction fluid.
• Do not write on any bar codes.
• You may use a calculator.

INFORMATION

• The total mark for this paper is 40.
• Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
• Any rough working should be done on this question paper.
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 Which statement is correct?
   A Cl has a relative isotopic mass of 35.5.
   B Cl₂ has a relative molecular mass of 70.
   C ICl has a relative molecular mass of 162.4.
   D NaCl has a relative molecular mass of 58.5.

2 Strontium metal can be extracted from strontium oxide, SrO, by reduction with aluminium. One of the possible reactions is shown.

   \[6\text{SrO} + 2\text{Al} \rightarrow 3\text{Sr} + \text{Sr}_3\text{Al}_2\text{O}_6\]

What is the maximum mass of strontium metal that can be produced from the reduction of 100 g of strontium oxide using this reaction?

A 41.3 g  B 42.3 g  C 84.6 g  D 169.2 g

3 A single \(^{32}\text{P}\) nucleus can be produced when a single \(^{32}\text{S}\) nucleus joins with particle X. In the process a proton is emitted.

What is particle X?

A a deuteron, \(^2\text{H}^+\)
B an electron
C a neutron
D a proton

4 In which of the following, when in liquid form, are there only intermolecular forces based on temporary dipoles between the particles?

A bromine
B ethanol
C hydrogen chloride
D water
5 Copper has a high melting point.

What is the reason for the high melting point of copper?
A strong attractive forces between copper atoms only
B strong attractive forces between copper ions and delocalised electrons
C strong attractive forces between copper ions only
D strong attractive forces between copper atoms and delocalised electrons

6 Which pair of standard enthalpy changes are numerically equal?
A atomisation of CH₄(g) and formation of CH₄(g)
B combustion of CH₃OH(l) and combustion of graphite + 2(combustion of H₂(g))
C combustion of graphite and formation of CO₂(g)
D neutralisation of HCl(aq) with NaOH(aq) and formation of H₂O(l)

7 An energy cycle is drawn for the following reaction.

\[
\text{Br}_2(1) + 3\text{F}_2(1) \rightarrow 2\text{BrF}_3(1)
\]

\[
2\text{Br}(g) + 6\text{F}(g) \quad +698 \text{ kJ}
\]

\[
\text{Br}_2(1) + 3\text{F}_2(1) \rightarrow 2\text{BrF}_3(1)
\]

The standard enthalpy of formation of BrF₃(l) = –301 kJ mol⁻¹.
The enthalpy change of BrF₃(l) to BrF₃(g) is +44 kJ mol⁻¹.

What is the average bond energy of the Br–F bond in BrF₃?
A 152 kJ mol⁻¹  B 202 kJ mol⁻¹  C 304 kJ mol⁻¹  D 404 kJ mol⁻¹

8 In which reaction does the greatest change in the oxidation number of sulfur occur?
A S(s) + O₂(g) → SO₂(g)
B SO₂(g) + \frac{1}{2}O₂(g) ⇄ SO₃(g)
C SO₃(g) + H₂SO₄(l) → H₂S₂O₇(l)
D H₂S₂O₇(l) + H₂O(l) → 2H₂SO₄(l)
9 The first stage in the chloride process for the manufacture of titanium consists of the following reaction.

\[ 2\text{TiO}_2 + 4\text{Cl}_2 + 3\text{C} \rightarrow 2\text{TiCl}_4 + 2\text{CO} + \text{CO}_2 \]

What is reduced in this reaction?
A carbon  
B chlorine  
C oxygen  
D titanium

10 In aqueous solution, sulfuric acid dissociates as shown.

\[ \text{H}_2\text{SO}_4 \rightarrow \text{HSO}_4^- + \text{H}^+ \]  
This reaction goes to completion.
\[ \text{HSO}_4^- \rightleftharpoons \text{SO}_4^{2-} + \text{H}^+ \]  
This reaction reaches equilibrium with constant \( K_c \).

Analysis of a 2.00 mol dm\(^{-3}\) solution of \( \text{H}_2\text{SO}_4 \) found the \( \text{HSO}_4^- \) concentration to be 1.988 mol dm\(^{-3}\).

What is \( K_c \)?
A \( 1.381 \times 10^5 \) dm\(^3\) mol\(^{-1}\)  
B 82.34 dm\(^3\) mol\(^{-1}\)  
C \( 1.214 \times 10^{-2} \) mol dm\(^{-3}\)  
D \( 7.244 \times 10^{-5} \) mol dm\(^{-3}\)

11 An autocatalytic reaction is a reaction in which one of the products catalyses the reaction.

Which curve would be obtained if the rate of an autocatalytic reaction is plotted against time?

A  
B  
C  
D
12 X and Y are two elements in Period 3 of the Periodic Table. They combine to form compound Z.

X forms a soluble acidic oxide. The oxidation number of X in this oxide is +4.

Y forms an amphoteric oxide.

What is the formula of compound Z?

A AlP  B Al₂S₃  C Si₂P₅  D SiS₂

13 This question is about two elements in Group 2, Q and R.

Three of the statements shown are correct for metal Q.

The one remaining statement is correct for metal R.

Which statement applies to R?

A A saturated solution of the hydroxide of this metal has the higher pH value.
B This metal has a carbonate that is used in agriculture to reduce the acidity of soil.
C This metal has the greater atomic radius.
D This metal reacts more quickly with cold water.

14 The electronic arrangement for atoms of four elements is given.

Which element is the strongest oxidising agent?

A 1s²2s²2p⁵  B 1s²2s²2p⁶3s²  C 1s²2s²2p⁶3s²3p⁵  D 1s²2s²2p⁶3s²3p⁶4s²

15 A student mixes pairs of chemicals together in separate test-tubes.

- excess calcium (s) + water (l)
- barium chloride (aq) + strontium hydroxide (aq)
- calcium carbonate (s) + excess hydrochloric acid (aq)
- magnesium sulfate (aq) + barium nitrate (aq)

How many of the mixtures produce a white, solid product?

A 0  B 1  C 2  D 3
16 With which compound does concentrated sulfuric acid react both as a strong acid and as an oxidising agent?

   A  magnesium carbonate
   B  potassium chloride
   C  sodium bromide
   D  sulfur trioxide

17 Ammonia can undergo an acid–base reaction with hydrogen chloride to form ammonium chloride. Which statement is correct?

   A  The ammonium ion is basic.
   B  The hydrogen atom from HCl donates a lone pair of electrons to the nitrogen atom.
   C  The H–N–H bond angle in ammonia is the same as the H–N–H bond angle in the ammonium ion.
   D  The H–N–H bond angle in the ammonium ion is the same as the H–C–H bond angle in methane.

18 What are the trends in the stated properties as Group 2 is descended from magnesium to barium?

<table>
<thead>
<tr>
<th></th>
<th>decomposition temperature of the carbonate</th>
<th>first ionisation energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>decreases</td>
<td>increases</td>
</tr>
<tr>
<td>B</td>
<td>decreases</td>
<td>decreases</td>
</tr>
<tr>
<td>C</td>
<td>increases</td>
<td>increases</td>
</tr>
<tr>
<td>D</td>
<td>increases</td>
<td>decreases</td>
</tr>
</tbody>
</table>

19 Sulfur dioxide, SO₂, reacts with calcium hydroxide in aqueous solution. What is the main product that is first formed?

   A  Ca(HSO₄)₂  B  CaS  C  CaSO₃  D  CaSO₄
20 Structural and stereoisomerism should be considered when answering this question.

Compounds X, Y and Z are shown.

How many other isomers of C₃H₇ClO are there that are alcohols?
A 2  B 3  C 4  D 5

21 Two students each make a statement about 2-methylbut-1-ene.

Student 1 states that 2-methylbut-1-ene has geometrical isomers.

Student 2 states that 2-methylbut-1-ene reacts with HBr in an addition reaction to give 1-bromo-2-methylbutane as the main product.

Which students are correct?
A both 1 and 2  B 1 only  C 2 only  D neither 1 nor 2

22 Which statement is correct when referring to the complete combustion of PVC?

A A gas is made which contributes to global warming.
B Carbon dioxide and water are the only products.
C If water is used to clean the exhaust gases, the water becomes alkaline.
D There is no need to treat the exhaust gases as the products are non-hazardous.

23 Iodoethane, CH₃CH₂I, reacts with aqueous silver nitrate at 50°C. A precipitate forms during this reaction.

Which row of the table is correct about this reaction?

<table>
<thead>
<tr>
<th></th>
<th>type of organic reaction</th>
<th>colour of precipitate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>electrophilic substitution</td>
<td>cream</td>
</tr>
<tr>
<td>B</td>
<td>electrophilic substitution</td>
<td>yellow</td>
</tr>
<tr>
<td>C</td>
<td>nucleophilic substitution</td>
<td>cream</td>
</tr>
<tr>
<td>D</td>
<td>nucleophilic substitution</td>
<td>yellow</td>
</tr>
</tbody>
</table>
24 A student converts 1-iodopropane, C₃H₇I, into butanoic acid, C₃H₇CO₂H, by a two-stage chemical synthesis.

In the first of the two stages, which reagent is reacted with 1-iodopropane?

A aqueous sodium hydroxide  
B ethanolic ammonia  
C ethanolic potassium cyanide  
D ethanolic sodium hydroxide

25 1-chloro-1-methylcyclohexane is hydrolysed by heating with NaOH(aq).

\[
\begin{align*}
\text{CH}_3 & \quad \text{OH}^- \\
\text{Cl} & \quad \text{OH}^- + \text{CH}_3 \quad \text{OH}^- + \text{Cl}^-
\end{align*}
\]

The reaction pathway is shown.

One carbon atom in 1-chloro-1-methylcyclohexane is bonded to three other carbon atoms.

What is the charge on this carbon atom at point Z?

A 1–  
B δ–  
C δ+  
D 1+

26 An alcohol with the molecular formula C₅H₁₂O decolourises warm acidified potassium manganate(VII). The alcohol also gives a yellow precipitate with alkaline aqueous iodine.

What could be the identity of the alcohol?

A 2-methylbutan-2-ol  
B 3-methylbutan-2-ol  
C pentan-1-ol  
D pentan-3-ol
27 Which pair of test results would prove that a substance, X, is a ketone?

A  X has no reaction with Tollens' reagent. X reacts with alkaline aqueous iodine.
B  X is reduced by lithium aluminium hydride. X is oxidised by acidified dichromate(VI).
C  X reacts with 2,4-DNPH reagent. X has no reaction with Fehling's reagent.
D  X reacts with hydrogen cyanide. X is reduced by lithium aluminium hydride.

28 Carvone is found in spearmint oil.

Which product is formed when carvone is reacted with NaBH₄?

A  
B  
C  
D  

29 Which compound is chiral and reacts with Na₂CO₃ to give CO₂?

A  
B  
C  
D  

30 The skeletal formula of compound X is shown.

What is the molecular formula of compound X?

A  C₁₀H₁₈O  B  C₁₀H₂₀O  C  C₁₁H₂₂O  D  C₁₁H₂₄O
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

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>1, 2 and 3 are correct</td>
<td>1 and 2 only are correct</td>
<td>2 and 3 only are correct</td>
</tr>
</tbody>
</table>

No other combination of statements is used as a correct response.

Use of the Data Booklet may be appropriate for some questions.

31 Nitrogen forms a number of oxides. Their enthalpies of formation are given.

\[
\Delta H^\circ_{f}[\text{NO}(g)] = +90 \text{ kJ mol}^{-1}
\]
\[
\Delta H^\circ_{f}[\text{N}_2\text{O}(g)] = +82 \text{ kJ mol}^{-1}
\]
\[
\Delta H^\circ_{f}[\text{NO}_2(g)] = +33 \text{ kJ mol}^{-1}
\]

Which statements are correct?

1. If \( \text{N}_2\text{O}(g) \) is oxidised by \( \text{O}_2(g) \) to \( \text{NO}_2(g) \), 16 kJ is released per mole of \( \text{N}_2\text{O} \).
2. The decomposition of \( \text{N}_2\text{O}(g) \) to \( \text{N}_2(g) \) and \( \text{O}_2(g) \) is exothermic.
3. The reaction between \( \text{NO} \) and oxygen is exothermic.

32 Which statements are correct?

1. enthalpy of combustion of \( \text{H}_2 \) = enthalpy of formation of \( \text{H}_2\text{O} \)
2. enthalpy of formation of \( \text{H}_2 \) = −(enthalpy of atomisation of \( \text{H}_2 \))
3. enthalpy of solution of \( \text{HCl} \) = enthalpy of hydration of \( \text{H}^+ \) + enthalpy of hydration of \( \text{Cl}^- \)

33 The units of \( K_c \) for an equilibrium reaction are \( \text{mol}^{-1} \text{ dm}^3 \).

What could be the equation for the equilibrium?

1. \( \text{A(aq)} + \text{B(aq)} \rightleftharpoons \text{C(s)} + \text{D(aq)} \)
2. \( \text{P(aq)} + \text{Q(aq)} \rightleftharpoons \text{R(aq)} \)
3. \( \text{W(aq)} + 2\text{X(aq)} \rightleftharpoons \text{Y(aq)} + \text{Z(aq)} \)
34 Methanol, CH₃OH, can be produced industrially by reacting CO with H₂.

\[
\text{CO(g)} + 2\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g}) \quad \Delta H = -91 \text{ kJ mol}^{-1}
\]

The process can be carried out at \(4 \times 10^3\) kPa and 1150 K.

Which statements about this reaction are correct?

1. Increasing the temperature will increase the rate of reaction because more effective collisions will occur.
2. Lowering the temperature will reduce the rate of reaction because the forward reaction is exothermic.
3. Increasing the pressure will reduce the rate of reaction because there are a larger number of moles on the left-hand side of the equation.

35 Which rows correctly show the relative electrical conductivities of the sets of three Period 3 elements?

<table>
<thead>
<tr>
<th></th>
<th>greatest conductivity</th>
<th>least conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>sodium</td>
<td>silicon</td>
</tr>
<tr>
<td>2</td>
<td>aluminium</td>
<td>magnesium</td>
</tr>
<tr>
<td>3</td>
<td>sulfur</td>
<td>silicon</td>
</tr>
</tbody>
</table>

36 Three test-tubes, X, Y and Z, each contain water.

- A small amount of NaCl is added to test-tube X.
- A small amount of SiCl₄ is added to test-tube Y.
- A small amount of AlCl₃ is added to test-tube Z.

After a short time, two drops of universal indicator solution are added to each test-tube.

Which statements can be correct?

1. The pH in test-tube X is 7.
2. The pH in test-tube Y is 2.
3. The pH in test-tube Z is 2.
The responses A to D should be selected on the basis of

<table>
<thead>
<tr>
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<td>1 only is correct</td>
</tr>
</tbody>
</table>

No other combination of statements is used as a correct response.

37  The structure of compound R is shown.

![compound R](image)

Which statements about compound R are correct?

1. It has an $M_r$ of 116.
2. It contains two groups that show strong absorptions between 1640 and 1740 cm$^{-1}$ in its infrared spectrum.
3. Its only infrared absorption between 2500 and 3000 cm$^{-1}$ is sharp and strong.

38  During the bromination of methane, the free radical CH$_3^+$ is generated. A possible termination step of this reaction is the formation of C$_2$H$_6$ by the combination of two free radicals.

What could be produced in a termination step during the bromination of **propane**?

1. CH$_3$CH$_2$CH(CH$_3$)CH$_2$CH$_3$
2. CH$_3$CH(CH$_3$)CH(CH$_3$)$_2$
3. CH$_3$CH$_2$CH$_2$CH(CH$_3$)$_2$
39 Three reactions of primary alcohols are listed.

Which reactions give water as one of the products?

1 reaction with ethanoic acid
2 reaction with concentrated HBr
3 passing the alcohol vapour over heated Al₂O₃

40 The diagram shows part of the structure of polymer X.

Which reagents react with polymer X?

1 aqueous sulfuric acid
2 aqueous sodium hydroxide
3 sodium