Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CHEMISTRY **0620/21**

Paper 2 Multiple Choice (Extended) **May/June 2017**

45 minutes

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

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, 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.
DO **NOT** WRITE IN ANY BARCODES.

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.

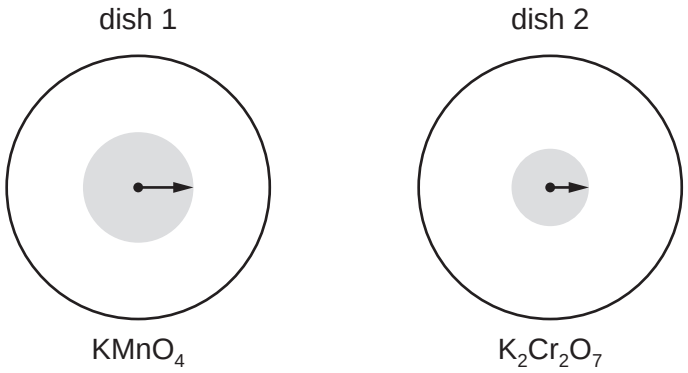
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
A copy of the Periodic Table is printed on page 16.
Electronic calculators may be used.

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 1/Level 2 Certificate.

This document consists of **16** printed pages.

1 Small crystals of purple $KMnO_4$ (M_r = 158) and orange $K_2Cr_2O_7$ (M_r = 294) were placed at the centres of separate petri dishes filled with agar jelly. They were left to stand under the same physical conditions.

After some time, the colour of each substance had spread out as shown.



The lengths of the arrows indicate the relative distances travelled by particles of each substance.

Which statement is correct?

A Diffusion is faster in dish 1 because the mass of the particles is greater.

B Diffusion is faster in dish 2 because the mass of the particles is greater.

C Diffusion is slower in dish 1 because the mass of the particles is smaller.

D Diffusion is slower in dish 2 because the mass of the particles is greater.

Answer

The correct answer is D: Diffusion is slower in dish 2 because the mass of the particles is greater.

Explanation:
Diffusion is the movement of particles from an area of higher concentration to an area of lower concentration.
The rate of diffusion is influenced by the molar mass of the diffusing particles; lighter particles diffuse faster than heavier particles.
Step 1: Compare the Molar Masses
Potassium permanganate ($KMnO_4$) has a molar mass of 158 g/mol.
Potassium dichromate ($K_2Cr_2O_7$) has a molar mass of 294 g/mol.
Step 2: Compare Diffusion Rates
From the diagram, diffusion is faster in dish 1 ($KMnO_4$) and slower in dish 2 ($K_2Cr_2O_7$).
Since $KMnO_4$ has a lower molar mass, its particles move and spread faster.
$K_2Cr_2O_7$ has a higher molar mass, so its particles diffuse more slowly.
Step 3: Choose the Correct Answer
A and B are incorrect because they incorrectly relate diffusion speed to mass.
C is incorrect because it says diffusion is slower in dish 1, but $KMnO_4$ diffuses faster.
D is correct because it correctly states that diffusion is slower in dish 2 due to the greater mass of $K_2Cr_2O_7$ particles.

Thus, the correct answer is D.

2 Pure water has a boiling point of 100 °C and a freezing point of 0 °C.

What is the boiling point and freezing point of a sample of aqueous sodium chloride?

	boiling point / °C	freezing point / °C
A	98	–2
B	98	2
C	102	–2
D	102	2

Answer

When a non-volatile solute like sodium chloride (NaCl) is dissolved in water, it causes two main effects on the properties of the solution. These effects are known as colligative properties:

Boiling Point Elevation:

The boiling point of a solution is higher than that of the pure solvent. This is because the solute particles interfere with the evaporation of the solvent molecules, requiring more energy (higher temperature) to reach the boiling point.
For an aqueous sodium chloride solution, the boiling point will be higher than 100 C.
Freezing Point Depression:

The freezing point of a solution is lower than that of the pure solvent. The solute particles disrupt the formation of the solid structure of the solvent, requiring a lower temperature to freeze.
For an aqueous sodium chloride solution, the freezing point will be lower than 0 C.
Now, let's evaluate each option:

Option A: Boiling point 98°C, Freezing point -2°C

This suggests both boiling point depression and freezing point depression, which is incorrect for a solution.
Option B: Boiling point 98°C, Freezing point 2°C

This suggests boiling point depression, which is incorrect, and freezing point elevation, also incorrect.
Option C: Boiling point 102°C, Freezing point -2°C

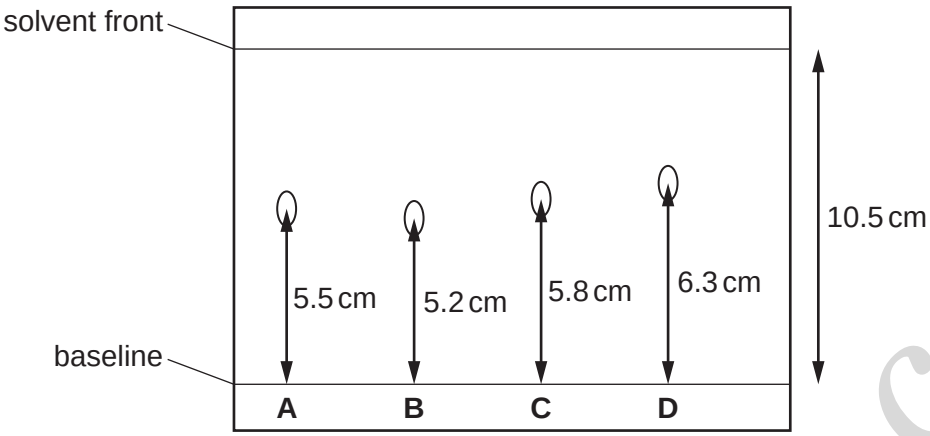
This indicates boiling point elevation and freezing point depression, which are the correct effects for an aqueous sodium chloride solution.
Option D: Boiling point 102°C, Freezing point 2°C

This suggests boiling point elevation but freezing point elevation, which is incorrect for a solution.

The correct answer is Option C, where the boiling point is elevated to 102°C and the freezing point is depressed to -2°C.

3 A chromatogram obtained from the chromatography of four substances is shown.

Which substance has an R_f value of 0.6?



Answer

To determine which substance has an Rf value of 0.6, we use the formula:

Rf = (Distance moved by substance) / (Distance moved by solvent)

From the image:

Solvent front distance = 10.5 cm
Distances moved by substances:
A = 5.5 cm
B = 5.2 cm
C = 5.8 cm
D = 6.3 cm
Now, we calculate the Rf values for each:

Rf for A = 5.5 ÷ 10.5 = 0.52
Rf for B = 5.2 ÷ 10.5 = 0.50
Rf for C = 5.8 ÷ 10.5 = 0.55
Rf for D = 6.3 ÷ 10.5 = 0.60
Since the Rf value of 0.6 matches substance D, the correct answer is:

Substance D.

4 Sodium reacts with chlorine to form sodium chloride.

Which statements describe what happens to the sodium atoms in this reaction?

1 Sodium atoms form positive ions.

2 Sodium atoms form negative ions.

3 Sodium atoms gain electrons.

4 Sodium atoms lose electrons.

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

Answer

In the reaction between sodium and chlorine to form sodium chloride, each element undergoes a change in its electron configuration:

Sodium (Na) is a metal that tends to lose electrons to achieve a stable electron configuration. When sodium loses one electron, it forms a positive ion (Na +).
Chlorine (Cl) is a non-metal that tends to gain electrons to achieve a stable electron configuration. When chlorine gains one electron, it forms a negative ion (Cl−).
Now, let's evaluate each statement regarding the sodium atoms:

Sodium atoms form positive ions.

This is true. Sodium atoms lose one electron and form positive ions (Na +).
Sodium atoms form negative ions.

This is false. Sodium atoms do not form negative ions; they form positive ions instead.
Sodium atoms gain electrons.

This is false. Sodium atoms lose electrons rather than gaining them.
Sodium atoms lose electrons.

This is true. Sodium atoms lose one electron to form positive ions.
Now let's evaluate each option:

Option A: 1 and 3

This suggests sodium atoms form positive ions and gain electrons, which is incorrect.
Option B: 1 and 4

This suggests sodium atoms form positive ions and lose electrons, which is correct.
Option C: 2 and 3

This suggests sodium atoms form negative ions and gain electrons, which is incorrect.
Option D: 2 and 4

This suggests sodium atoms form negative ions and lose electrons, which is incorrect.

The correct answer is Option B, where sodium atoms form positive ions and lose electrons.

5 Diamond is extremely hard and does not conduct electricity.

Which statement explains these properties?

A It has a lattice of positive carbon ions in a 'sea of electrons'.

B It has delocalised electrons and each carbon atom forms three covalent bonds with other carbon atoms.

C It has no delocalised electrons and each carbon atom forms four covalent bonds with other carbon atoms.

D It has strong ionic bonds between each carbon atom.

Answer

To understand the properties of diamond, we need to consider its structure and bonding characteristics:

Diamond is a form of carbon where each carbon atom is covalently bonded to four other carbon atoms in a three-dimensional tetrahedral structure. This gives diamond its extreme hardness.

In this structure, there are no free or delocalized electrons available to conduct electricity, which is why diamond does not conduct electricity.

Now, let's evaluate each statement:

Option A: It has a lattice of positive carbon ions in a 'sea of electrons'.

This describes metallic bonding, which is not applicable to diamond.
Option B: It has delocalised electrons and each carbon atom forms three covalent bonds with other carbon atoms.

This describes graphite, another form of carbon, where there are delocalized electrons and each carbon atom bonds with three other carbon atoms. This is not applicable to diamond.
Option C: It has no delocalised electrons and each carbon atom forms four covalent bonds with other carbon atoms.

This accurately describes the structure of diamond, explaining why it is hard and does not conduct electricity.
Option D: It has strong ionic bonds between each carbon atom.

Carbon atoms in diamond are not bonded ionically; they are covalently bonded.

The correct answer is Option C, where diamond has no delocalised electrons and each carbon atom forms four covalent bonds with other carbon atoms.

6 Which statement about metals is **not** correct?

A Metals are malleable because the metal ions can slide over one another.

B Metals conduct electricity because electrons can move through the lattice.

C Metals consist of a giant lattice of metal ions in a ‘sea of electrons’.

D Metals have high melting points because of the strong attraction between the metal ions.

Answer

Let's examine each statement about metals to determine which one is not correct:

Option A: Metals are malleable because the metal ions can slide over one another.

This statement is correct. Metals are malleable because the layers of metal ions can slide over each other without breaking the metallic bonds.
Option B: Metals conduct electricity because electrons can move through the lattice.

This statement is correct. Metals conduct electricity because they have delocalized electrons that can move freely through the lattice.
Option C: Metals consist of a giant lattice of metal ions in a 'sea of electrons'.

This statement is correct. Metals have a structure where positively charged metal ions are surrounded by a 'sea of electrons' that are free to move, which accounts for many of their properties.
Option D: Metals have high melting points because of the strong attraction between the metal ions.

This statement is not entirely correct. While metals do typically have high melting points, the reason is due to the strong attraction between the metal ions and the delocalized electrons, not just between the metal ions themselves.

The statement that is not fully correct is Option D, as it does not accurately describe the nature of the bonding in metals that leads to their high melting points.

7 Aluminium reacts with fluorine.

$$x\mathit{Al}(s) + y F_2(g) \rightarrow z\mathit{Al}F_3(s)$$

Which values of *x*, *y* and *z* balance the equation?

	x	*y*	*z*
A	1	2	1
B	2	3	2
C	3	2	3
D	4	3	4

Answer

To balance the chemical equation for the reaction between aluminum (Al) and fluorine (F2) to form aluminum fluoride (AlF3), we need to ensure that the number of atoms of each element is equal on both sides of the equation.

The unbalanced equation is: x Al (s) + y F2 (g) → z AlF3 (s)

Let's balance it step by step:

Aluminum (Al): Aluminum fluoride (AlF3) contains one aluminum atom. Therefore, if we have z AlF3, we need z aluminum atoms. So x = z.

Fluorine (F2): Aluminum fluoride (AlF3) contains three fluorine atoms. For z AlF3, we need 3z fluorine atoms. Since fluorine is diatomic (F2), we need (3z / 2) F2 molecules.

Now, let's check the options:

Option A: x = 1, y = 2, z = 1

This gives 1 aluminum and 2 fluorine molecules (4 fluorine atoms), which does not balance with 3 fluorine needed for 1 AlF3.
Option B: x = 2, y = 3, z = 2

This gives 2 aluminum and 6 fluorine atoms (from 3 F2), which balances with 2 AlF3 (2 aluminum and 6 fluorine).
Option C: x = 3, y = 2, z = 3

This gives 3 aluminum and 4 fluorine atoms, which does not balance with 9 fluorine needed for 3 AlF3.
Option D: x = 4, y = 3, z = 4

This gives 4 aluminum and 6 fluorine atoms, which does not balance with 12 fluorine needed for 4 AlF3.

The correct option is B: x = 2, y = 3, z = 2. This balances the equation as:
2 Al (s) + 3 F2 (g) → 2 AlF3 (s)

8 Carbon monoxide burns in oxygen to produce carbon dioxide.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

Which mass of carbon dioxide is produced from 14 g of carbon monoxide?

A 22 g **B** 28 g **C** 44 g **D** 88 g

Answer

To find the mass of carbon dioxide produced from 14 grams of carbon monoxide, we need to use the stoichiometry of the reaction and the molar masses of the substances involved.

The balanced chemical equation is: 2 CO (g) + O2 (g) → 2 CO2 (g)

Calculate the molar mass:

Molar mass of CO (carbon monoxide) = 12 (carbon) + 16 (oxygen) = 28 g/mol
Molar mass of CO2 (carbon dioxide) = 12 (carbon) + 2 * 16 (oxygen) = 44 g/mol
Use stoichiometry of the reaction:

From the equation, 2 moles of CO produce 2 moles of CO2.
Therefore, 1 mole of CO (28 g) produces 1 mole of CO2 (44 g).
Calculate the mass of CO2 from 14 g of CO:

If 28 g of CO produces 44 g of CO2, then 14 g of CO will produce:
(14 g CO) * (44 g CO2 / 28 g CO) = 22 g CO2

The correct answer is A: 22 g.

9 Which statement about electrolysis is correct?

A Electrons move through the electrolyte from the cathode to the anode.

B Electrons move towards the cathode in the external circuit.

C Negative ions move towards the anode in the external circuit.

D Positive ions move through the electrolyte towards the anode during electrolysis.

Answer

To determine the correct statement about electrolysis, let's review how electrolysis works:

Electrons and Electrolytes:

In electrolysis, an external power source causes electrons to move through the external circuit.
Electrons do not move through the electrolyte; instead, they move through the external circuit.
Movement of Electrons:

Electrons move from the power source towards the cathode in the external circuit.
Thus, electrons move towards the cathode.
Movement of Ions:

In the electrolyte, negative ions (anions) move towards the anode, where they release electrons.
Positive ions (cations) move towards the cathode, where they gain electrons.
Now, let's evaluate each statement:

Option A: Electrons move through the electrolyte from the cathode to the anode.

This is incorrect. Electrons move through the external circuit, not through the electrolyte.
Option B: Electrons move towards the cathode in the external circuit.

This is correct. Electrons flow towards the cathode in the external circuit during electrolysis.
Option C: Negative ions move towards the anode in the external circuit.

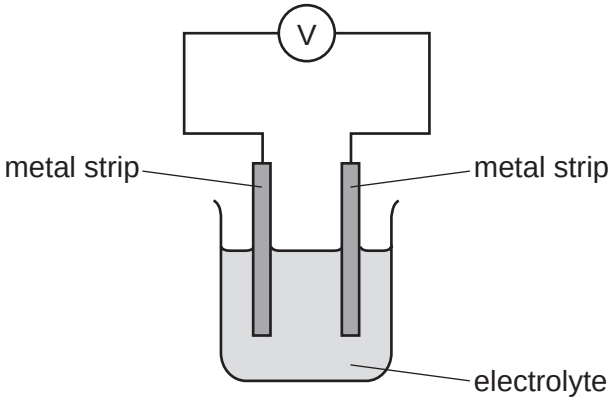
This is incorrect. Negative ions move towards the anode, but within the electrolyte, not in the external circuit.
Option D: Positive ions move through the electrolyte towards the anode during electrolysis.

This is incorrect. Positive ions move towards the cathode, not the anode, during electrolysis.
The correct statement is B: Electrons move towards the cathode in the external circuit.

10 The reactivity series for a number of different metals is shown.

most reactive →					least reactive
magnesium	zinc	iron	copper	silver	platinum

The diagram shows different metal strips dipped into an electrolyte.



Which pair of metals produces the highest voltage?

A copper and magnesium

B magnesium and platinum

C magnesium and zinc

D silver and platinum

Answer

Step 1: Understanding the Concept
The voltage produced in an electrochemical cell depends on the difference in reactivity between the two metals.
A larger difference in reactivity results in a higher voltage.
The more reactive metal loses electrons (oxidation), while the less reactive metal gains electrons (reduction).
Step 2: Identifying the Reactivity of the Given Metals
From the reactivity series in the diagram:

Magnesium (most reactive)
Zinc
Iron
Copper
Silver
Platinum (least reactive)
Step 3: Evaluating the Answer Choices
We need to find the pair of metals with the greatest reactivity difference:

A (Copper and Magnesium) → Magnesium is highly reactive, and copper is much less reactive. Large difference
B (Magnesium and Platinum) → Magnesium is very reactive, and platinum is the least reactive. Largest difference
C (Magnesium and Zinc) → Both are reactive, but the difference is smaller than the previous options
D (Silver and Platinum) → Both are very unreactive, so the voltage will be very low
Step 4: Choosing the Correct Answer
Since magnesium is the most reactive and platinum is the least reactive, this pair will produce the highest voltage.
The correct answer is B: Magnesium and Platinum.