(c) Extension parts of the syllabus

Some parts of the syllabus form the extension. Only questions in Section B of the examination paper will involve these parts.

Sections	Topics of the extension part
1 Planet Earth	—
2 The Microscopic World	• Predicting the chemical properties of unfamiliar elements in Groups I, II, VII and 0 of the Periodic Table
3 Metals	• Empirical formulae derived from experimental data • Corrosion resistance of aluminum • Anodisation as a method to enhance corrosion resistance of aluminium
4 Acids and Alkalis	• Strength of acids and alkalis • Preparation of soluble and insoluble salts based on neutralisation • Simple volumetric work involving acids and alkalis • Rate of reaction
5 Chemical Cells and Electrolysis	• Nitric acid of different concentrations as oxidizing agent to give NO and NO_2 • Reactions in chemical cells consisting of half cell(s) other than metal-metal ions systems • Reactions in zinc-carbon cell • Electrolysis
6 Products from Important Processes	• Manufacture of chlorine by electrolysis of brine • Designing and performing experiments to make chlorine bleach • Molar volume of gases at room temperature and pressure • Calculations involving molar volume of gases • Chemical plants
7 Fossil Fuels and of Carbon Compounds	—
8 Plastics and Detergents	• Condensation polymerization as exemplified by the formation of nylon and polyester • Production of soaps by reacting fats or oils with an alkali • Cleaning abilities of soaps and soapless detergents in hard water • Environmental problems associated with the use of detergents
9 Detection and Analysis	• Designing and performing an investigation to deduce the chemical nature of a given sample

3 Metals

Concept Map

Metals

Occurrence and extraction of metals

Occurrence of metals
- Most metals are found in the Earth as ores.
- Most reactive metals are present as chlorides, carbonates or oxides.
- Less reactive metals are present as sulphides.
- Unreactive metals are present in a free state.

Extraction of metals by reduction
- Metal oxide $\xrightarrow{\text{Heat}}$ Metal + O_2
  (HgO and Ag_2O)
- Metal oxide + C → Metal + CO_2
  (ZnO, Fe_2O_3, PbO and CuO)
- Metal oxide + CO → Metal + CO_2
  (ZnO, Fe_2O_3, PbO and CuO)
- Metal oxide + H_2 → Metal + H_2O
  (Fe_2O_3, PbO and CuO)

Discovery of metals with the ease of extraction and their availability
- Metals discovered early are less reactive.
- Less abundant metals are more expensive.

Conservation of metals
- Reasons for conservation of metals
- Methods of conserving metals
  (1) Reusing metals
  (2) Replacing metals
  (3) Recycling metals

Reactivity of metals

Reaction of metals with oxygen
Metal + O_2 → Metal oxide
e.g. $2Zn(s) + O_2(g) \rightarrow 2ZnO(s)$

Reaction of metals with water / steam
Metal + Water → Metal hydroxide + H_2
e.g. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$
Metal + Steam → Metal oxide + H_2
e.g. $Zn(s) + H_2O(g) \rightarrow ZnO(s) + H_2(g)$

Reaction of metals with dilute acid (HCl / H_2SO_4)
Metal + Acid → Salt + H_2
e.g. $Zn(s) + 2HCl(g) \rightarrow ZnCl_2(s) + H_2(g)$

Metal reactivity series
- The most reactive metal is placed at the top of the series.
- The most reactive metal loses electrons most readily to form positive ion.
- The tendency of elements to lose electrons decreases across a period and increases down a group in the Periodic Table.

Displacement reactions
A more reactive metal will displace a less reactive metal from its aqueous solution.
e.g. $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$

Reacting masses

Mole, Avogadro's constant and molar mass

- Definitions
- Number of moles

$$= \frac{\text{Mass of the substance in (g)}}{\text{Molar mass in (g / mol)}} \quad \text{OR}$$

$$= \frac{\text{Number of particles}}{\text{Avogadro's number}}$$

Percentage by mass of an element in a compound

$$= \frac{\text{Atomic number of an element} \times \text{Number of element in the compound}}{\text{Formula mass of the compound}} \times 100\%$$

Empirical formula Extension

Methods of calculating empirical formula:
(1) percentage by mass of the elements; and
(2) experimental data.

Equations

Different types of equation:
(1) Word equation
(2) Chemical equation
(3) Ionic equation

Use of equations for calculation

Corrosion of metals and their protection

Corrosion of metals

- Corrosion is the slow reaction of metal with air (oxygen), water or other substances.
- Corrosion of iron is called rusting.

Conditions for rusting

(1) Water
(2) Air (oxygen)

Factors affecting the rate of rusting

(1) Temperature
(2) Presence of electrolytes
(3) Sharply pointed regions
(4) Presence of another metal

Methods of rust prevention

- Surface protection
  (1) Painting
  (2) Oiling / Greasing
  (3) Coating with plastics
  (4) Metal plating
- Sacrificial protection
- Alloying of iron

Socioeconomic implications of iron

Corrosion of aluminium Extension

1.3 Rocks and minerals

Learning Focus

- Recognize that rocks are the source of minerals.
- Learn the method of isolating useful materials from minerals, for example, the extraction of metals from their ores.
- Recognize that limestone, chalk and marble are different forms of calcium carbonate.
- Study the weathering and erosion of rocks.
- Explore the thermal decomposition of calcium carbonate.
- Learn the tests for the presence of calcium and carbonate in a sample of limestone, chalk or marble.

A. Rocks as the source of minerals

- The rock of the Earth is a solid mass of a mixture of minerals（礦物質）.
- Minerals are naturally occurring metal compounds. They have definite crystalline structures and chemical compositions.
- Since many metals are very reactive, they do not exist as free elements. They occur naturally in rocks as compounds in ores（礦石）.
- An ore is a rock that has a lot of a metal compounds.
- These ores are usually metal oxides and sulphides which are mixed with impurities.
- The following table shows the various metals in ores:

Metals	Ores	Metal compounds present in the ore
Sodium	Rock salt	Sodium chloride
Aluminium	Bauxite	Aluminium oxide
Zinc	Zinc blende	Zinc sulphide
Iron	Haematite	Iron(III) oxide
Lead	Galena	Lead(II) sulphide
Copper	Copper pyrite	Copper iron sulphide

Table 1.4

Reminder

Rocks are the source of a wide range of minerals. There are three types of rock:
(1) igneous rock;
(2) sedimentary rock; and
(3) metamorphic rock.

3.4 Corrosion of metals and their protection

Learning Focus

- Recognize the factors affecting the rusting of iron.
- Learn the methods for preventing iron from rusting, e.g. painting, oiling, coating with plastics, tin-plating, sacrificial protection and alloying.
- Understand the socioeconomic implications of corrosion of metals.
- Recognize the corrosion of aluminium. Extension
- Use anodisation to enhance the corrosion resistance of aluminium. Extension

A. Corrosion of metals

- Corrosion（腐蝕作用）is the slow reaction of metal with air, water or other substances in the environment.
- The more reactive metals corrode at a faster rate than the less reactive ones. For example, sodium metal corrodes at a faster rate than copper metal.
- The corrosion of iron is called rusting（生銹）.
- In the first stage of rusting, iron(II) ions are produced from iron metal.

$$Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$$

- Iron(II) ions are then involved in a series of chemical changes. The overall change can be simplified as:

$$4Fe(s) + 2nH_2O(l) + 3O_2(g) \rightarrow \underbrace{2Fe_2O_3 \cdot nH_2O(s)}$$

hydrated iron(III) oxide = rust（銹） (reddish brown)

Reminder

- The equation of rusting is simplified and unbalanced.
- Water and oxygen are involved in the chemical reaction for iron rusting.

B. Conditions for rusting

- Water and air are essential for rusting.
- The following experiment shows the need of water and air for rusting:

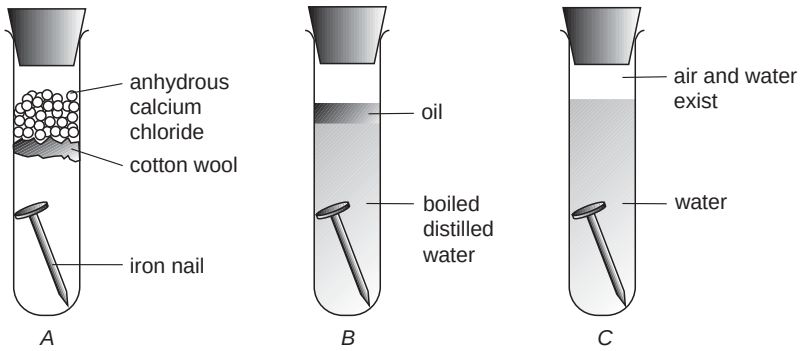

Figure 3.13

Reminder

- Anhydrous（無水的）calcium chloride ($CaCl_2$) is used to absorb water.
- The word 'anhydrous' must be stated when $CaCl_2$ is used to absorb water.

- Interpretation
  The rate of formation of carbon dioxide gas is found to be greater when using powdered calcium carbonate.

Guided Example 21

A student added 1 g of powdered calcium carbonate to 40 cm^3 of 1.0 M hydrochloric acid at room temperature and atmospheric pressure. The volume of gas was collected and recorded. The result is graphically represented by curve *X*:

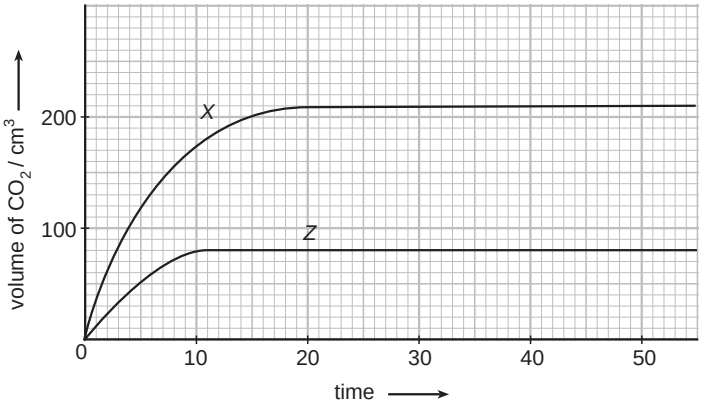

Figure 4.49

(a) Using the same mass of calcium carbonate in the form of marble chips, curve *Y* should be obtained. Sketch curve *Y* on the above graph.

(b) Curve *Z* was obtained when 1.0 g of marble chip was put in 40 cm^3 of 0.5 M sulphuric acid. A student told his teacher the sketched curve *Z* was wrong. Comment on the student's suggestion.
(Assuming there is no change in the temperature and it is under atmospheric pressure.)

Reminder

The surface areas of powdered calcium carbonate and marble chips are different.

Suggested Answer

(a)

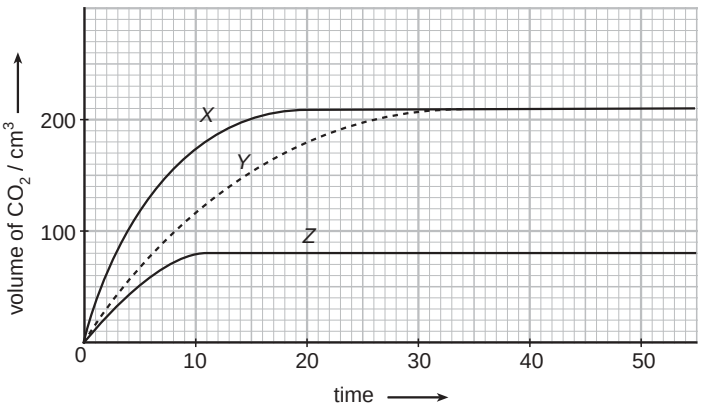

Figure 4.50

(b) The student is wrong.
The final volume of carbon dioxide gas obtained was so small.
This is because a protective layer of calcium sulphate forms on the surface of calcium carbonate.
This layer stops further reaction between calcium carbonate and acid.

- Interpretation
  - An increase in temperature increases the rate of reaction.
  - The graph of (1 / t vs. T) is NOT a straight line. This indicates that a smaller rise in temperature would greatly increase the reaction rate.

Reminder

1 / t represents the rate of reaction.

Guided Example 22

One of the components of an egg shell is calcium carbonate. A student added 50 cm^3 of 2 M hydrochloric acid to 0.1 g of egg shells in a container. After half an hour, all the egg shells had dissolved and carbon dioxide was collected and recorded.

(a) Write an ionic equation for the reaction between calcium carbonate and hydrochloric acid.

(b) The time taken for the reaction was very long. Suggest TWO ways to increase the rate of this reaction without using other chemicals. Explain your answer.

Reminder

'Without using chemical' means that catalyst or larger amount of egg shells cannot be used to fasten the rate of reaction.

Suggested Answer

(a) $CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

(b)
- Crushing the egg shells / making egg shells into powdered form to increase the surface area. A faster reaction rate would be expected.
- Heating the mixture / increasing the temperature would increase the rate of chemical reaction. This is because there is a larger number of particles with enough energy (activation energy) for successful collisions.

Reminder

Calcium carbonate ($CaCO_3$) is insoluble in water, so CO_3^{2-} cannot be written in the ionic equation.

Glossary

acid	酸	neutral	中性的
acidic	酸性的	neutralisation	中和作用
acidity	酸度	pH meter	pH 計
alkali	鹼	pH value	酸鹼值
alkaline	鹼性的	pipette	移液管
alkalinity	鹼度	precipitate	沉澱物
basicity	鹼度 / 鹽基度	standard solution	標準溶液
burette	滴定管	strong acid	強酸
concentration	濃度	strong alkali	強鹼
crystal	晶體	titration	滴定〔法〕
crystallization	結晶	universal indicator	通用指示劑
data logger	數據記錄儀	volumetric analysis	容量分析
evaporation	蒸發	volumtric flask	容量瓶
filtrate	濾液	water of crystallization	結晶水
filtration	過濾	weak acid	弱酸
indicator	指示劑	weak alkali	弱鹼
molarity	摩爾濃度		

Important Formulae

$$\text{Number of moles} = \frac{\text{Mass of substance in (g)}}{\text{Molar mass in (g / mol)}} = \frac{\text{Number of particles}}{\text{Avogadro's number}}$$

$$\text{Molarity of a solution (M or mol dm}^{-3}\text{)} = \frac{\text{Number of moles of solute}}{\text{Volume of solution (in dm}^3\text{)}}$$

$$\text{Concentration of a solution (g dm}^{-3}\text{)} = \frac{\text{Mass of a substance}}{\text{Volume of solution (in dm}^3\text{)}}$$

Examination Question Analysis

Topics	Conventional Questions (Year)	Multiple-choice Questions (Year)
Acids	93(3b, 4b), 94(1), 95(7a), 98(4, 8), 00(1), 01(2), 03(1b), 04(8a), 05(3b)	93(23), 94(15, 16, 28), 95(46), 96(15, 33), 97(31, 39, 50), 98(9, 23), 99(37), 01(35), 02(19, 32, 48), 04(44), 05(14, 29, 38)
Alkalis	96(6b), 98(3, 4), 01(2), 02(6a, 9a)	97(35, 37), 98(25), 99(20), 00(29), 01(3, 11), 02(17, 24), 03(45)
Indicators and pH	97(3)	02(5)
Strength of acids and alkalis	96(6b), 00(7a), 03(4)	94(33)
Neutralisation and salts	93(1b), 95(5), 96(1), 97(7a), 98(6a), 00(4, 6a), 02(7a), 05(3a)	93(43), 94(31), 95(49), 96(6,10), 97(13), 98(12, 31), 00(11, 22, 49), 03(43), 04(8)
Concentration of solutions	97(7a), 05(3c)	93(49), 97(6), 00(20), 03(20), 05(22, 34)
Simple volumetric work	93(1b, 4b), 94(5a, 8a), 99(7b), 00(7a), 01(6a), 02(9b), 03(8b), 04(7a)	94(30), 95(8, 9, 12, 16), 96(28, 49), 97(14), 98(16, 28), 99(6, 25), 01(34), 02(26), 03(30), 05(39, 40, 41)
Rate of reaction	93(4b), 94(8a), 05(10)	93(39, 40), 05(50)

Demonstration

Paper I Conventional Questions

Section A

1. 'Sunday spring water' is a brand of bottled water. The following label shows the concentration of ions in the water:

Concentration of ions in 'Sunday spring water'

Ions	(mg / l)	Ions	(mg / l)
Chloride	16	Sodium	12
Nitrate	4	Potassium	1
Sulphate	10	Magnesium	22
Hydrogencarbonate	160	Calcium	48

Table 1.6

(a) (i) Name TWO metal ions present in the water which give coloured flames in the flame test.

(ii) 'The flame test can be used to identify cations in the spring water.' Do you agree this statement. Explain your answer.

(b) (i) Which TWO ions in 'Sunday Spring Water' come from the mixing of rainwater with chalk rocks?

(ii) Write a word equation for the reaction between rainwater and chalk rocks.

(9 marks)

Guidelines

Chalk rocks contain calcium carbonate.

Suggested Answer

(a) (i) *Calcium ion* has a *brick red* flame. 1 + 1
Potassium ion has a *lilac* flame. 1 + 1
Sodium ion has a *golden yellow* flame. 1 + 1
(Any two)

(ii) *Disagree.*
This is because there *are some cations / positive ions* in the water. These ions *produce their own flame colour.* 1 + 1

(b) (i) *Calcium and hydrogencarbonate ions.* 1 + 1

(ii) Calcium carbonate + Carbon dioxide + Water → Calcium hydrogencarbonate 1

Guidelines

Students should remember the following metal ions flame colours:

- Na^+: golden yellow flame
- K^+: lilac / purple flame
- Ca^{2+}: brick-red flame
- Cu^{2+}: bluish green flame

Paper II Multiple-choice Questions

Section A

1. Which of the following is a correct representation of the atomic structure of atom $^{65}_{30}X$?

	Number of protons	Number of neutrons	Number of electrons
A.	30	30	65
B.	35	35	30
C.	30	35	30
D.	35	30	35

Answer: C

Guidelines

- Atomic number = Proton number = Electron number
- Mass number = Proton number + Neutron number

2. Which of the following statements about water molecule is / are correct?

(1) It is formed by electron transfer.
(2) It has low conductivity of electricity.
(3) It is a giant covalent substance.

A. (1) only
B. (2) only
C. (1) and (2) only
D. (2) and (3) only

Answer: B

Guidelines

Water molecules are held by weak van der Waals' forces.

3. Which of the following pairs has an equal number of electrons?

A. Ne, Na^+
B. O^{2-}, S^{2-}
C. Ar, F^-
D. Na^+, Mg^+

Answer: A

Guidelines

Students should write down the electronic arrangement of each pair first.

4. The electronic arrangement of an element $^{11}_{5}X$ (X is represented as a symbol) is

A. 5
B. 6
C. 2, 3
D. 2, 5

Answer: C

Guidelines

The electron number is equal to the atomic number, which is equal to 5. So the electronic arrangement of X is 2, 3.

Practice

Paper I Conventional Questions

Section A

1. The following table gives some information about *P*, *Q*, *R*, *S* and *T*. Which represent either atoms or ions?

Elements	Atomic number	Mass number	Number of electrons	Number of neutrons	Number of protons
P	9	19	9		9
Q	9		10	11	
R	10		10	10	
S	17	35			
T		37	17		17

Table 2.25

(a) *R* is monatomic. Explain why? Hint 1

(b) (i) Which particle(s) is / are the ions? Hint 2
(ii) What is the relationship between *P* and *Q*?
(iii) Do particles of *P* and *Q* have the same chemical properties? Explain your answer.

(c) (i) Suggest a term to indicate the relationship between *S* and *T*.
(ii) Explain why *S* and *T* have the same chemical properties.
(iii) (1) Hydrogen can react with *S* to form a molecule. Draw the electronic structure of this molecule. Give the formula for this molecule. Hint 3
(2) Calculate the relative molecular mass of the compound formed.

(11 marks)

2. The diagram below represents an anion of atom *X*:

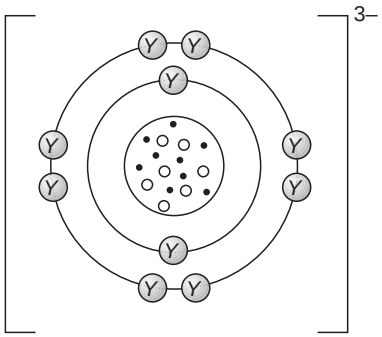

Figure 2.57