Chemistry

Chemical Earth + Metals

Theory Test • 2006

General Instructions

- Reading time – 5 minutes
- Working time – 70 minutes
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A Data Sheet and a Periodic Table are provided at the back of this paper and may be removed for convenience
- Write your Student Number at the top of this page

Total Marks – 45

Part A – 14 marks
- Attempt Questions 1 – 14
- Allow about 20 minutes for this part

Part B – 31 marks
- Attempt Questions 15 – 22
- Allow about 50 minutes for this part

Part A – 14 marks
Attempt Questions 1 – 14
Allow about 20 minutes for this part

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 =   (A) 2   (B) 6   (C) 8   (D) 9

A ◯   B ●   C ◯   D ◯

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ●   B ✖   C ◯   D ◯

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word *correct* and drawing an arrow as follows.

correct

A ✖   B ✖   C ◯   D ◯

Answer Box for Questions 1 – 14

1	A ◯	B ◯	C ◯	**D ●**
2	A ◯	B ◯	C ◯	**D ●**
3	A ◯	B ◯	**C ●**	D ◯
4	**A ●**	B ◯	C ◯	D ◯
5	A ◯	**B ●**	C ◯	D ◯
6	A ◯	B ◯	**C ●**	D ◯
7	**A ●**	B ◯	C ◯	D ◯
8	A ◯	**B ●**	C ◯	D ◯
9	A ◯	**B ●**	C ◯	D ◯
10	A ◯	B ◯	**C ●**	**D ●**
11	**A ●**	B ◯	C ◯	D ◯
12	A ◯	B ◯	**C ●**	D ◯
13	**A ●**	B ◯	C ◯	D ◯
14	A ◯	**B ●**	C ◯	D ◯

1   Which of the following is a liquid non–metal at 25°C *?*

(A)   water
(B)   mercury
(C)   chlorine
(D)   bromine

2   Which of the following is **not** a property of metals*?*

(A)   shiny
(B)   conducts heat
(C)   malleable
(D)   brittle

3   Which procedure best describes a method for separating a mixture of liquids*?*

(A)   crystallization
(B)   filtration
(C)   distillation
(D)   froth floatation

4   Which of the following reactions is incorrect*?*

(A)   silver chloride   →   silver + chlorine + light
(B)   copper(II) carbonate + heat   →   copper(II) oxide + carbon dioxide
(C)   magnesium + oxygen + heat   →   magnesium oxide + light + heat
(D)   water + electricity   →   hydrogen + oxygen

5   Which of the following exists as a covalent lattice*?*

(A)   argon
(B)   carbon
(C)   hydrogen
(D)   mercury

6   Which alloy and property matches its common use?

	Alloy	Property
(A)	solder	high melting point
(B)	brass	hardness
(C)	steel	strength
(D)	bronze	low density

7   Which element has the highest electronegativity?

(A)   chlorine
(B)   iodine
(C)   rubidium
(D)   sodium

8   Which of the following correctly identifies the conducting species when electricity is passed through these substances?

	Substance		
	mercury	molten NaCl	graphite
(A)	cations	cations & anions	electrons
(B)	electrons	cations & anions	electrons
(C)	electrons	cations & anions	atoms
(D)	cations	electrons	electrons

9   Which of the following substances does not exist as a molecule?

(A)   helium
(B)   sodium chloride
(C)   carbon dioxide
(D)   water
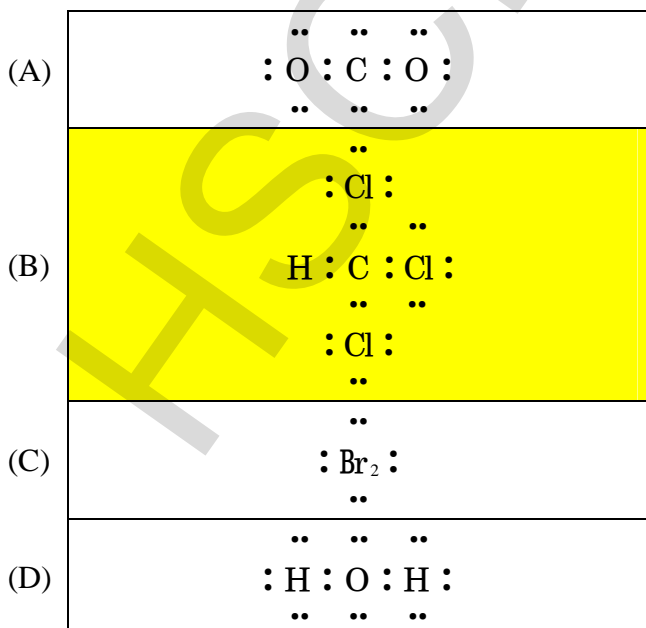
10   How many gaseous elements are there at 25°C?

(A)   9
(B)   10
(C)   11
(D)   12   ► *If element 118, Ununoctium (Uuo) is accepted*

11 Which statement best describes Mendeleev's theory for the classification of elements?

(A) The chemical and physical properties of elements vary in relation to their atomic weights.
(B) The physical properties of elements vary in relation to their atomic weight.
(C) The chemical and physical properties of elements vary in relation to their atomic number.
(D) The chemical properties of elements vary in relation to their atomic number.

12 The energy input necessary to extract a metal from its ore may be affected by several factors…

(i) the reactivity of the metal
(ii) the density of the metal
(iii) the magnetic property of the metal
(iv) the chemical composition of the ore of ore

Which factor(s) will have the greatest effect on the size of the energy input?

(A) (i), (ii), (iii) only
(B) (i) and (ii) only
(C) (i) and (iv) only
(D) (i) only

13 Which of the following correctly shows the synthesis of magnesium oxide as an ionic substance?

(A) $Mg + \frac{1}{2} O_2 \rightarrow Mg^{2+} O^{2-}$

(B) $Mg + O \rightarrow Mg^{+} O^{-}$

(C) $Mg + 2O \rightarrow O^{-} Mg^{2+} O^{-}$

(D) $Mg + O_2 \rightarrow Mg^{2+} O_2^{2-}$

14 Which of the following Lewis electron dot structures is correct?

(A)
```
  ··   ··   ··
: O : C : O :
  ··   ··   ··
```

(B)
```
        ··
      : Cl :
        ··   ··
  H : C : Cl :
        ··   ··
      : Cl :
        ··
```

(C)
```
    ··
: Br₂ :
    ··
```

(D)
```
  ··   ··   ··
: H : O : H :
  ··   ··   ··
```

Part B – 31 marks
Attempt Questions 15 – 22
Allow about 50 minutes for this part

► *Show all relevant working in questions involving calculations.*

Question 15   (3 marks)

(a)   Describe the periodic trend for the first ionisation energy of the Group II elements.   **(1 mark)**

The first ionisation energy decreases going down the group.

(b)   Explain the implications of this trend for the relative chemical reactivity of the Group II elements. **(2 marks)**

The relative reactivity of metals increases going down the group. This trend results from the increasing ease at which the valence shell electron(s) are lost from the metals going down the group. That is, the first ionisation decreases going down the group.

(1 mark) Distinguishing the trend in relative reactivity of the elements in Group II - it increases.
(1 mark) Associating the trend with the ease at which electrons are lost from the elements. That is, increasing ease of losing the valence shell electrons going down the group.

Question 16   (2 marks)

Hundreds of metals and alloys are available to engineers for specific uses.

(a)   Suggest **two** relevant characteristics required for a metal used in a knee implant.   **(1 mark)**

The metal must be…
- *non-toxic*
- *not rejected by body tissue*
- *very strong*
- *not corroded in the tissue*
- *able to be finely machined, light*

Any two of the criteria for 1 mark

(b)   Suggest **two** relevant characteristics required for a metal used in an exterior door of an aircraft. **(1 mark)**

The metal should…
- *not melt or fracture or change shape at the high/low temperatures to which it may be subjected*
- *not corrode or react with any material in contact with it*
- *be light*
- *be strong*

► *Any two of the above criteria for 1 mark*

Question 17   (4 marks)

Five metals A, B, C, D, E are placed in solutions containing cations A^{2+}, B^{2+}, C^{2+}, D^{2+}, E^{3+}.
The results of the experiment are shown below…

	A	B	C	D	E
A^{2+}	no visible reaction	reaction observed	no visible reaction	reaction observed	reaction observed
B^{2+}	no visible reaction	no visible reaction	no visible reaction	reaction observed	no visible reaction
C^{2+}	reaction observed	reaction observed	no visible reaction	reaction observed	reaction observed
D^{2+}	no visible reaction	no visible reaction	no visible reaction	no visible reaction	no visible reaction
E^{3+}	no visible reaction	reaction observed	no visible reaction	reaction observed	no visible reaction

(a)   List the metals in order of increasing reactivity.   **(1 mark)**
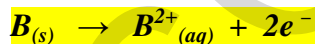
$C < A < E < B < D$

(b)   For the reaction between B and E^{3+} construct…

(i)   a balanced formula equation   **(1 mark)**

$3B_{(s)} + 2E^{3+}_{(aq)} \rightarrow 3B^{2+}_{(aq)} + 2E_{(s)}$

► *The equation must be balanced to get the mark.*

(ii)   two half–equations representing electron transfer   **(2 marks)**

$B_{(s)} \rightarrow B^{2+}_{(aq)} + 2e^-$

$E^{3+}_{(aq)} + 3e^- \rightarrow E_{(s)}$

► *Two correct equations for 1 mark.*

Question 18   (6 marks)

Substances P, Q, R and S were found to have the following properties…

Substance / Properties	P	Q	R	S
Melting point (°C)	660	– 30	854	2700
Electrical conductivity	good conductor when solid or liquid	non-conductor	good conductor when liquid	non-conductor
Solubility in water	insoluble	insoluble	soluble	insoluble

Complete the table classifying the structure of each substance (covalent molecular, covalent network, ionic, or metallic) and give a reason for your classification.

	Structure classification	Reason for classification
P	metallic	Substance P conducts both in the solid or liquid phase indicating the existence of mobile charge carriers which must be electrons since conduction occurs as well, in the solid phase as in the liquid phase.
Q	covalent molecular	The very low melting point and non-conductivity of substance Q indicate that it is covalent molecular. The absence of mobile charge carriers prevents it from conducting. Only weak intermolecular forces exist between the Q molecule, hence its low melting point.
R	ionic	Conductivity in the liquid state and non-conductivity in the solid phase show it to be made up of ions, fixed in the lattice in the solid phase but free to move in the liquid phase due to the breakdown of the lattice.
S	covalent network	Insolubility in any solvent and a very high melting point indicates strong non-polar covalent bonding between atoms in a three dimensional lattice.

Question 19   (4 marks)

Account for the use of an identified metal and non-metal in terms of their physical properties.

Answer ~

	Use	Physical Property
Metal	*copper* — *electrical wiring*	*conducts electricity*
Non–metal	*carbon/diamond* — *cutting tools*	*very hard*

Marking Criteria	Marks
• *Correct **use of** a named metal **linked to a property** AND correct **use of** a named non-metal **linked to a property**.*	4
• *3 of the above*	3
• *Correct use of a named metal and a named non-metal OR correct use of a named metal linked to a property OR correct use of a named non-metal linked to a property.*	2
• *Correct use of a named metal OR correct use of a named non-metal.*	1

Question 20   (4 marks)

During your practical work, you performed a first-hand investigation to determine the percentage composition of a mixture using gravimetric analysis. Describe the mixture you used, the steps in your method, the physical properties that allowed your method to be valid.

The mixture was of sand, salt and water. The initial mass of the mixture was calculated by subtracting the mass of the beaker from the total mass.

The sand separated from the mixture using filtration. The mass of sand can be calculated by subtracting the mass of the filter paper. (Sand does not dissolve in water.)

The filtrate is heated and the water is evaporated to leave the salt. (Salt dissolves in water and crystallises out when the water is evaporated. The mass of the salt can be calculated by subtracting the mass of the evaporating basin.

Marking Criteria	Marks
detailed description and physical properties	4
detailed description of the method	3
brief description of the method	2

Question 21   (4 marks)

(a)   The table shows some information about an ion. Complete the table.   **(2 marks)**

|	
Charge	1 +
Mass Number	24
Atomic Number	11
Number of neutrons	*13*
Number of electrons	*10*
Number of protons	*11*
Electron configuration	*2 – 8*

►   *All four correct = 2 marks*
      Two or three correct = 1 mark
      One correct = 0

(b)   Construct formulae for the products of these synthesis reactions…   **(2 marks)**

iodine + aluminium	AlI_3
carbon + sulfur	CS_2
phosphate ion + calcium ion	$Ca_3(PO_4)_2$
hydroxide ion + iron(III) ion	$Fe(OH)_3$

►   *All four correct = 2 marks*
      Two or three correct = 1 mark
      One correct = 0

Question 22   (4 marks)

(a)   The diagrams show two samples of liquid water containing **ten** molecules…

Complete the diagrams showing the result after boiling and electrolysis.   **(3 marks)**

PARTICLE VIEW AFTER COMPLETE BOILING	PARTICLE VIEW AFTER COMPLETE ELECTROLYSIS
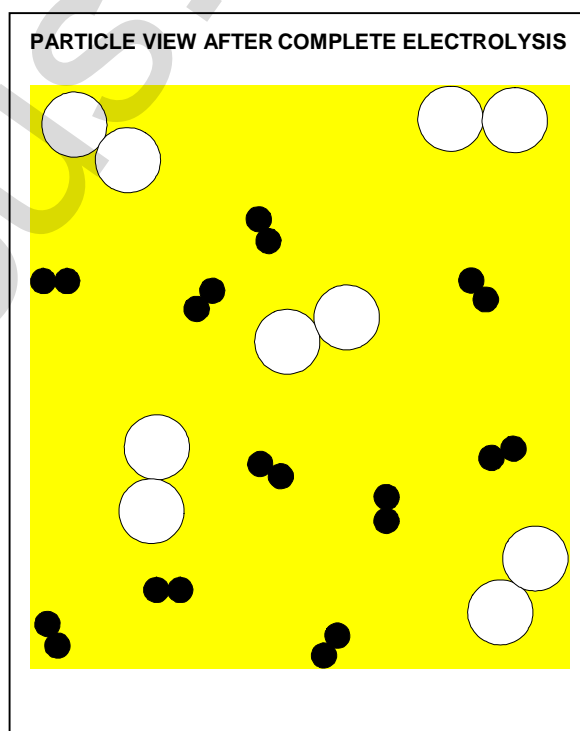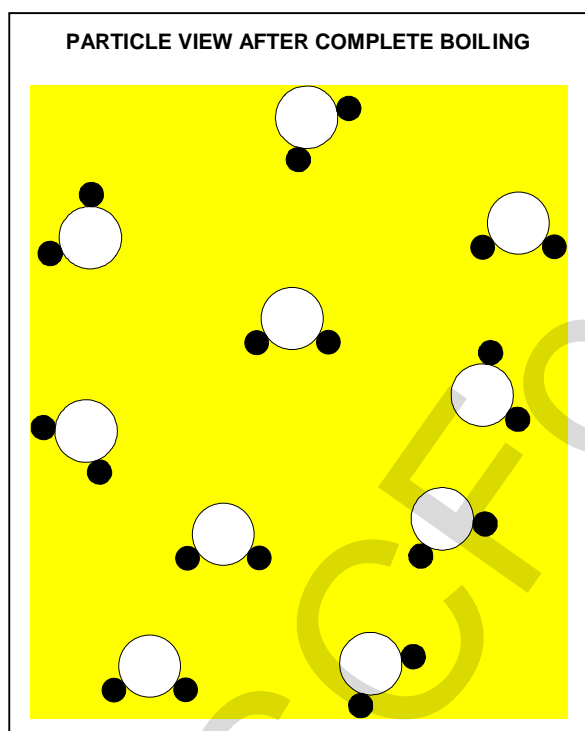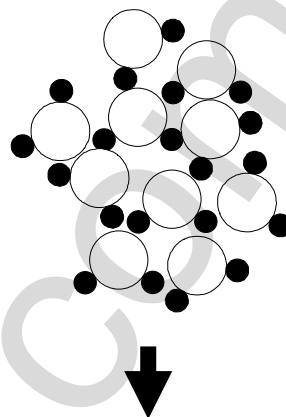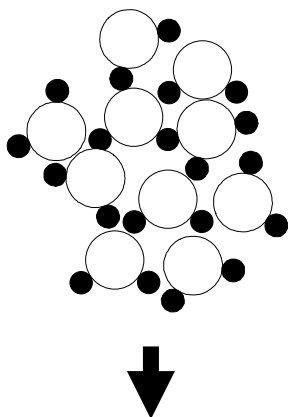
► *Correct boiling and electrolysis depiction with adequate free space   (2 marks)*

► *Conservation of mass   (1 mark)*

(b)   To electrolyse one gram of water requires seven times more energy than to boil one gram of water. Explain the large difference.   **(1 mark)**

The electrolysis of water is a chemical change involving the breaking of the H – O covalent bonds, whereas boiling is a physical change involving the breaking of weaker intermolecular forces and the spreading out of the molecules.