# Unit 1 · Fundamentals of Chemistry

**ANSWER KEY · FOR TEACHERS**

Full marks 33

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

## 1 Key words

1. compound
2. atomicity
3. isotopes
4. atomic mass unit
5. cation
6. -ite
7. empirical formula
8. formula unit

K · 4

Each carries 0.5 mark.

## 2 Label the diagram

1. fire
2. cold water
3. vapor rises
4. fermented grain and water

K · 2

Each carries 0.5 mark.

## 3 Multiple choice

**i.** **c.** tin(IV) — K · 1

The Stock name gives the charge as a Roman numeral: $Sn^{4+}$ is tin(IV). Stannous is the classical name of the lower ion, $Sn^{2+}$, tin(II).

**ii.** **c.** $HCO_3^-$ — U · 1

An acid radical is an anion, a negative ion that comes from an acid: the hydrogen carbonate ion, $HCO_3^-$. The other three are cations (basic radicals); $NH_4^+$ is a polyatomic one.

**iii.** **c.** 20 — U · 1

Each $NH_4^+$ has 5 atoms, and there are three of them: 15. $PO_4^{3-}$ has 5 more. In all 15 + 5 = **20**.

**iv.** **b.** 40% — A · 1

$M_r(MgO) = 24 + 16 = 40$, so % O = 16/40 × 100% = **40%**. 60% is the share of magnesium; 50% is the share of the atoms, not of the mass.

**v.** **c.** $C_5H_{10}O_5$ — A · 1

Empirical formula mass = 12 + 2 + 16 = 30, so n = 150/30 = 5: $(CH_2O) \times 5 = \mathbf{C_5H_{10}O_5}$.

## 4 Short answers

**a.** MARKING SCHEME — U · 2

- ✓ A weighted average of the masses of its isotopes.
- ✓ A ratio of two masses, so it has no unit.

**b.** MARKING SCHEME — U · 2

- ✓ 2N: two separate atoms; $N_2$: one molecule of two bonded atoms.
- ✓ $2N_2$: two molecules, 4 atoms in all.

**c.** MARKING SCHEME — A · 3

- ✓ $Mg_3N_2$.
- ✓ $(NH_4)_2Cr_2O_7$.
- ✓ $Pb(NO_3)_2$.



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## 5 Long answer

**ANSWER** U · 4

An **ion** is an atom or group of atoms that carries a charge, because it has lost or gained electrons.
A **cation** is a positive ion, formed by losing electrons ($Na^+$, $Fe^{3+}$, $NH_4^+$); an **anion** is a negative ion, formed by gaining electrons ($Cl^-$, $SO_4^{2-}$).
$Fe^{2+}$ is the **ferrous** ion, iron(II); $Fe^{3+}$ is the **ferric** ion, iron(III). The classical names add -ous for the lower valency and -ic for the higher; the Stock name gives the charge as a Roman numeral.
Iron(II) sulphate: $Fe^{2+}$ and $SO_4^{2-}$, **$FeSO_4$**. Iron(III) chloride: $Fe^{3+}$ and $Cl^-$, **$FeCl_3$**.

**MARKING SCHEME**

- ✓ An ion is a charged atom or group of atoms (electrons lost or gained).
- ✓ A cation is positive (electrons lost), an anion negative (electrons gained).
- ✓ $Fe^{2+}$ ferrous, iron(II); $Fe^{3+}$ ferric, iron(III).
- ✓ $FeSO_4$ and $FeCl_3$.

## 6 Numerical problems

**a.** **ANSWER** A · 4

i. $M_r = 24 + 32 + 4 \times 16 + 7 \times 18 = 24 + 32 + 64 + 126 =$ **246**.
ii. % water $= 126/246 \times 100\% =$ **51.22%**.
iii. % Mg $= 24/246 \times 100\% =$ **9.76%**.
iv. Water $= 12.3 \times 126/246 =$ **6.3 g**.

**MARKING SCHEME**

- ✓ $M_r = 246$ (the water added, $7 \times 18$).
- ✓ Water 51.22%.
- ✓ Magnesium 9.76%.
- ✓ 6.3 g of water.

**b.** **ANSWER** A · 4

i. $Ar = \dfrac{51.8 \times 106.91 + 48.2 \times 108.90}{100} = \dfrac{5537.9 + 5249.0}{100} =$ **107.87**.

ii. Let x% be lithium-6: $6.94 = \dfrac{6.015x + 7.016(100 - x)}{100}$, so 694 = 701.6 − 1.001x, and x = 7.6 ÷ 1.001 = **7.6%** (the rest, 92.4%, is lithium-7).

**MARKING SCHEME**

- ✓ The weighted average set up for silver.
- ✓ $A_r(Ag) = 107.87$.
- ✓ The equation for lithium with x% and (100 − x)%.
- ✓ 7.6% lithium-6.

## 7 Think

**ANSWER** HA · 3

Not necessarily. The same percentage composition means the same **empirical formula**: 40.0/12 : 6.7/1 : 53.3/16 = 3.33 : 6.7 : 3.33 = 1 : 2 : 1, $CH_2O$. But many compounds share an empirical formula (glucose, $C_6H_{12}O_6$, and acetic acid, $C_2H_4O_2$, are both $CH_2O$).
Measure the **molecular mass** of each: n = molecular mass ÷ 30 gives the molecular formula, $(CH_2O)_n$. If the molecular masses differ, so do the compounds.

**MARKING SCHEME**

- ✓ Same composition gives only the same empirical formula, $CH_2O$.
- ✓ Different compounds can share an empirical formula (an example).
- ✓ The molecular mass is needed to find each molecular formula.


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## 8 Activity: Chemistry on the kitchen shelf

(not marked)

### WHAT STUDENTS SHOULD FIND

For example: table salt, sodium chloride, NaCl, $M_r = 23 + 35.5 = 58.5$, 39.3% sodium; baking soda, sodium hydrogen carbonate, $NaHCO_3$, $M_r = 23 + 1 + 12 + 48 = 84$, 27.4% sodium. The percentage is large when the element's atoms are heavy and numerous compared with the rest of the formula. Every percentage is by mass, not by number of atoms.

| Marks by level | Knowledge | Understanding | Application | Higher ability | Total |
|---|---|---|---|---|---|
| **Marks** | 7 | 10 | 13 | 3 | **33** |



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