



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. matter
2. nucleus
3. neutrons
4. atomic number
5. shells
6. valence electrons
7. valency
8. molecular formula

K • 4

Each carries 0.5 mark.

2 Label the diagram

1. nucleus
2. K shell, $n = 1$ energy level 1: up to $2 \times 1^2 = 2$ electrons
3. L shell, $n = 2$ energy level 2: up to $2 \times 2^2 = 8$ electrons

4. M shell, $n = 3$ energy level 3: up to $2 \times 3^2 = 18$ electrons
5. N shell, $n = 4$ energy level 4: up to $2 \times 4^2 = 32$ electrons
6. energy increases away from the nucleus

A • 3

Each carries 0.5 mark.

3 Multiple choice

- i. c. neutron and proton

K • 1

The nucleus holds the protons and neutrons; the electrons move in shells around it.

- ii. c. neon

K • 1

Neon (2, 8) already has a full outer shell, so it loses, gains and shares nothing. Hydrogen and sodium have valency 1, calcium 2.

- iii. b. 2, 8, 6

U • 1

Fill from the inside: K takes 2, L takes 8, and the 6 left go into M: 2, 8, 6. "2, 14" forgets that the L shell holds only 8; "2, 6, 8" fills in the wrong order.

- iv. a. CaO

A • 1

Calcium has valency 2 and oxygen has valency 2. Crossing gives Ca_2O_2 , and dividing by 2 gives CaO. CaCO_3 is calcium carbonate (limestone).

- v. d. argon

A • 1

Add protons and neutrons: potassium $19 + 20 = 39$, carbon 12, oxygen 16, argon $18 + 22 = 40$. Argon is heavier than potassium, even though potassium has the larger atomic number.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ Valence shell.

- b. MARKING SCHEME

A • 1

✓ $18 (2 \times 3^2)$.

- c. MARKING SCHEME

A • 1

✓ 23 amu.



5 Short answers

a. MARKING SCHEME

U • 2

- ✓ Any one difference, e.g. a proton is positively charged (p^+); an electron is negatively charged (e^-).
- ✓ Any second difference, e.g. a proton is in the nucleus and has a mass of 1 amu; an electron moves in the shells and has a mass of about $1/1836$ amu.

b. MARKING SCHEME

U • 2

- ✓ An atom has as many electrons as protons, and the neutrons have no charge.
- ✓ The positive charge of each proton and the negative charge of each electron are equal, so they cancel.

c. MARKING SCHEME

A • 2

- ✓ Valency 1.
- ✓ It has 1 valence electron; losing it leaves a full outer shell of 8 (2, 8, 8), much easier than gaining 7.

6 Long answers

a. ANSWER

A • 4

- She drew 6 protons: sodium has 11 (its atomic number). She drew 8 neutrons: sodium has 12 ($11 + 12 = 23$ amu). She drew 10 electrons: sodium has 11.
- 2, 8, 1: the L shell is filled with 8 before any electron goes into the M shell (she drew 2, 7, 1).

MARKING SCHEME

- ✓ Mistake 1: 6 protons drawn; sodium has 11.
- ✓ Mistake 2: 8 neutrons drawn; sodium has 12.
- ✓ Mistake 3: 10 electrons drawn; sodium has 11.
- ✓ The correct configuration 2, 8, 1 (the L shell holds 8 before the M shell starts).

b. ANSWER

U • 4

The atomic number is 19, so the element is potassium (K). Draw a nucleus marked $19p^+$ and $20n^0$, with 2 electrons in the K shell, 8 in L, 8 in M and 1 in N. To find the atomic weight we need the number of protons and the number of neutrons, because nearly all the mass of an atom is in its nucleus; electrons are so light (about $1/1836$ amu) that they are left out. Here $19 + 20 = 39$ amu.

MARKING SCHEME

- ✓ Potassium (K), because 19 protons means atomic number 19.
- ✓ A drawing of the nucleus ($19p^+$, $20n^0$) with 19 electrons in four shells: 2, 8, 8, 1.
- ✓ The number of protons and the number of neutrons are needed.
- ✓ Reason: nearly all the mass is in the nucleus (electrons are about $1/1836$ amu, too light to count); $19 + 20 = 39$ amu.

7 Numerical problem

ANSWER

A • 2

H: 2 atoms, $2 \times 1 = 2$; S: 1 atom, 32; O: 4 atoms, $4 \times 16 = 64$; 7 atoms in all. Molecular weight = $2 + 32 + 64 = 98$ amu.

MARKING SCHEME

- ✓ The atoms counted: 2 H, 1 S, 4 O (7 in all).
- ✓ Molecular weight = $2 \times 1 + 32 + 4 \times 16 = 98$ amu.



8 Think

ANSWER

HA · 2

No, not as a neutral atom. An atom must have as many electrons as protons to be neutral. If all its electrons are removed, what is left is just a positively charged nucleus, an **ion**, not an atom; it behaves completely differently and quickly grabs electrons from anything nearby. (A hydrogen atom without its one electron is a bare proton, H^+ .) Also, it is the electrons that let an atom join with other atoms in chemical reactions.

MARKING SCHEME

- ✓ No: a neutral atom must have as many electrons as protons; with all its electrons removed, what is left is a positively charged nucleus, an ion, not an atom.
- ✓ It is the electrons that let an atom join with other atoms in reactions (a bare nucleus quickly grabs electrons from anything nearby).

9 Activity: Shells and valency

(not marked)

WHAT STUDENTS SHOULD FIND

Lithium 2, 1: 1 valence electron, valency 1 (loses). Nitrogen 2, 5: 5, valency 3 (gains). Neon 2, 8: 8, valency 0 (neither). Magnesium 2, 8, 2: 2, valency 2 (loses). Sulphur 2, 8, 6: 6, valency 2 (gains). Calcium 2, 8, 8, 2: 2, valency 2 (loses). With 1–3 valence electrons an atom loses them; with 5–7 it gains enough to make 8.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	7	9	15	2	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. atomic number
2. group
3. period
4. alkali metals
5. halogens
6. inert gases
7. reactants
8. skeleton equation

K • 4

Each carries 0.5 mark.

2 Label the diagram

- | | |
|------------|------------|
| 1. 2, 8, 1 | 5. 2, 8, 5 |
| 2. 2, 8, 2 | 6. 2, 8, 6 |
| 3. 2, 8, 3 | 7. 2, 8, 7 |
| 4. 2, 8, 4 | 8. 2, 8, 8 |

U • 4

Each carries 0.5 mark.

3 Multiple choice

- i. b. Henry Moseley

K • 1

Moseley found the atomic numbers in 1913, and the modern periodic table arranges the elements by atomic number. Mendeleev made an earlier table arranged by atomic weight.

- ii. d. atomic number

K • 1

By **atomic number**, as the modern periodic law says. Atomic weight and atomic mass mean the same thing here, and were the basis of Mendeleev's older table.

- iii. c. elements in the same group have the same valency

U • 1

Elements in a group have the same number of valence electrons, so the **same valency**. The other three are the wrong way round: properties are similar, size increases down a group, and non-metallic character decreases.

- iv. b. both are in the same period

U • 1

Chlorine (2, 8, 7) and argon (2, 8, 8) both have **3 shells**, so both are in **period 3**. Chlorine is a very reactive halogen in group 17; argon is an inert gas in group 18.

- v. c. group 17, a very reactive non-metal (a halogen)

A • 1

It has 7 valence electrons, so it gains 1 electron to become stable: a very reactive non-metal of **group 17**. (It is chlorine.) Elements with 7 valence electrons are in group 17, not group 7: in the modern table, groups 3 to 12 are the transition metals in the middle.

4 Very short answers

- a. MARKING SCHEME

K • 1

✓ 18 groups and 7 periods.

- b. MARKING SCHEME

K • 1

✓ Mercury.



- c. MARKING SCHEME A • 1
✓ Period 4 (it has 4 shells).

5 Short answers

- a. MARKING SCHEME U • 2
✓ Any one difference, e.g. a group is a vertical column; a period is a horizontal row (18 groups, 7 periods).
✓ Any second difference, e.g. elements in a group have the same number of valence electrons and similar properties; elements in a period have the same number of shells and properties that change step by step.
- b. MARKING SCHEME U • 2
✓ Sodium (2, 8, 1) has 1 valence electron and chlorine (2, 8, 7) has 7, so they are in different groups (1 and 17).
✓ Sodium loses 1 electron and chlorine gains 1 electron to become stable, so both have valency 1.
- c. MARKING SCHEME U • 2
✓ The metallic character increases down a group.
✓ Each element has one more shell, so its valence electrons are farther from the nucleus, held less tightly, and lost more easily.
- d. MARKING SCHEME A • 2
✓ Zinc sulphate, ZnSO_4 , and hydrogen, H_2 , as the products.
✓ $\text{Zn} + \text{H}_2\text{SO}_4 \rightarrow \text{ZnSO}_4 + \text{H}_2$ (balanced: 1 Zn, 2 H, 1 S, 4 O on each side).

6 Long answers

- a. ANSWER U • 4
This is group 2, the alkaline earth metals. (1) Each has 2 valence electrons (Be 2, 2; Mg 2, 8, 2; Ca 2, 8, 8, 2), so each has valency 2. (2) They are metals: they lose their 2 valence electrons in reactions. (3) Their atomic size increases from Be to Ca, as a shell is added at each step. (4) Their metallic character and reactivity increase going down. (5) They have similar chemical properties: each forms an oxide MO (BeO, MgO, CaO).
MARKING SCHEME
✓ Any one characteristic, e.g. each has 2 valence electrons, so valency 2.
✓ Any second, e.g. they are metals that lose 2 electrons in reactions.
✓ Any third, e.g. the atomic size increases from Be to Ca (one more shell at each step).
✓ Any fourth, e.g. the metallic character and reactivity increase down the group; or similar chemical properties (oxides BeO, MgO, CaO).
- b. ANSWER A • 4
i. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$
ii. $2\text{K} + \text{Cl}_2 \rightarrow 2\text{KCl}$
iii. $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$
iv. $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
MARKING SCHEME
✓ i. $\text{CaCO}_3 + 2\text{HCl} \rightarrow \text{CaCl}_2 + \text{H}_2\text{O} + \text{CO}_2$ (correct formulas $\frac{1}{2}$, balanced $\frac{1}{2}$).
✓ ii. $2\text{K} + \text{Cl}_2 \rightarrow 2\text{KCl}$ (correct formulas $\frac{1}{2}$, balanced $\frac{1}{2}$).
✓ iii. $4\text{Na} + \text{O}_2 \rightarrow 2\text{Na}_2\text{O}$ (correct formulas $\frac{1}{2}$, balanced $\frac{1}{2}$).
✓ iv. $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$ (correct formulas $\frac{1}{2}$, balanced $\frac{1}{2}$).



7 Balancing equations

ANSWER

A · 2

$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$. Check: N 2 = 2; H 6 = 6 (3×2 on the left, 2×3 on the right).

MARKING SCHEME

- ✓ $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$.
- ✓ The atoms counted on both sides: N 2 and 2, H 6 and 6.

8 Think

ANSWER

HA · 2

Metals have 1–3 valence electrons and lose them, while non-metals have 5–7 and gain electrons. Their properties are opposite. The periodic table puts elements in order of atomic number, so the number of valence electrons rises across each period: elements that lose electrons (metals) end up on the left and in the middle, and elements that gain electrons (non-metals) on the right.

MARKING SCHEME

- ✓ Metals have 1–3 valence electrons and lose them; non-metals have 5–7 and gain electrons, so their properties are opposite.
- ✓ In order of atomic number the valence electrons rise across each period, so the metals come on the left and in the middle and the non-metals on the right.

9 Activity: Find each element's seat

(not marked)

WHAT STUDENTS SHOULD FIND

2, 1 lithium: group 1, period 2, metal. 2, 6 oxygen: group 16, period 2, non-metal. 2, 8, 2 magnesium: group 2, period 3, metal. 2, 8, 7 chlorine: group 17, period 3, non-metal. 2, 8, 8 argon: group 18, period 3, inert gas. 2, 8, 8, 1 potassium: group 1, period 4, metal. The number of shells gives the period; the valence electrons give the group (1 and 2 for groups 1 and 2, 3 to 8 for groups 13 to 18).

See it at Science Playground

Exhibits and plants at the center, Bhaktapur, that go with this unit. Book a class visit at science-playground.com/booking.

- **The Giant Periodic Table (exhibit):** Find your favorite element's group and period on a periodic table 4 meters long.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	8	16	10	2	36

