

Atomic Structure

Mark Scheme 5

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Atomic Structure
Sub-Topic	
Paper Type	Theory
Booklet	Mark Scheme 5

Time Allowed: 73 minutes

Score: /61

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1. (a) (i)

halogen	melting point/°C	colour
chlorine	-10	green, yellow or greenish-yellow
bromine	-7	orang or red or brown
iodine	114	grey accept black

chlorine and bromine **both** correct
iodine correct **for solid**

(1)

- (ii) down the Group
there are more electrons in the molecule
hence stronger van der Waals' forces

(1)

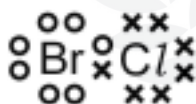
(1) [4]

(b) (i)

chlorine	$2s^2 2p^6 3s^2 3p^5$
bromine	$2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$
or	$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^5$

both needed (1)

(ii)



(1)

- (c) (i) gas **or** low boiling liquid
BrCl has fewer electrons than Br₂
hence weaker van der Waals' forces

(1)

(1)

(1)

- (ii) accept colours in the range yellow, orange, red, brown

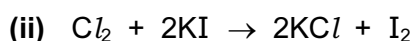
(1)

[4]

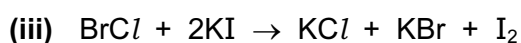
- (d) (i) **initially** solution begins to turn yellow/brown
after several minutes black/dark grey solid formed

(1)

(1)



(1)



(1)

- (iv) as oxidising agents

(1)

[5]

[Total: 15]

2. (a) a (d-block) element forming stable ions/compounds/oxidation states with incomplete/partially filled [NOT empty] d-orbitals [1] [1]
- (b) (i) $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^3 4s^2$ [1]
(ii) $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^9$ [1] [2]
- (c) (+)2, (+)3, (+)4, (+)5 or II, III, IV, V [1] [1]
- (d) (pale blue solution \Rightarrow) blue/cyan **solid/ppt.** (or (s) in the formula) [1]
(blue ppt. is) $\text{Cu}(\text{OH})_2$ or copper hydroxide [1]
(then produces a) deep blue or purple **solution** [1]
which contains $[\text{Cu}(\text{NH}_3)_4]^{2+}$ or $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$ [1]
formed by ligand replacement [1] [5]
- (e) $2\text{VO}_3^- + 8\text{H}^+ + \text{Cu} \longrightarrow 2\text{VO}^{2+} + 4\text{H}_2\text{O} + \text{Cu}^{2+}$
or $2\text{VO}_2^+ + 4\text{H}^+ + \text{Cu} \longrightarrow 2\text{VO}^{2+} + 2\text{H}_2\text{O} + \text{Cu}^{2+}$
correct species [1]
balancing [1]
(award only [1] for just the two half-equations) [2]

[Total: 11]

CHEMISTRY ONLINE
— TUITION —

3. (a) same proton number/atomic number (1)
different mass number/nucleon number (1) [2]

(b) $A_r = \frac{(24 \times 78.60) + (25 \times 10.11) + (26 \times 11.29)}{100}$ (1)

$$= \frac{1886.4 + 252.75 + 293.54}{100} = \frac{2432.69}{100}$$

which gives $A_r = 24.33$ (1)
penalise (-1) for misuse of significant figures [2]

(c)

isotopes	number of		
	protons	ne	electrons
^{226}Ra		138	88
^{238}U	9	146	92

allow **one mark** for each correct column (3 × 1)
if there are no correct columns,
allow **maximum one mark** for a correct row [3]

(d) (i) Ra^{2+} (1)

(ii) less than (502 + 966) (1)
allow answers in the range 1000–1400 kJ mol⁻¹ (1)

ionisation energies decrease down the Group
or must be less than IE for Ba → Ba²⁺
or size of atom increases down Group/
electrons are further away from nucleus
or there is increased shielding down Group (1)

allow ecf on answer to (i) [3]

[Total: 10]

4. (a)

	1s	2s	2p	3s	3p	3d	4s	4p	4d
Ca	2	2	6	2	6	0	2	0	0
Sr ²⁺	2	2	6	2	6	10	2	6	

[1]

[1]

[2]

(b) (i) more shells of electrons

[1]

(ii) outermost shell has been removed

[1]

(iii) outermost electrons are further from nucleus/there are more shells
increased shielding

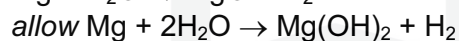
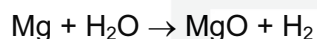
[1]

[1] [4]

(c) (i) very slow reaction
formation of bubbles of gas

[1]

[1]



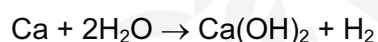
[1]

(ii) faster reaction than with Mg

[1]

white suspension formed
or evolution of gas
or calcium dissolves/disappears

[1]



[1]

allow 1 mark in (i) or (ii) if gas is described as colourless

[1] [7]

(d) (i) gas evolved
gas is brown

[1]

[1]

(ii) $2\text{Sr}(\text{NO}_3)_2 \rightarrow 2\text{SrO} + 4\text{NO}_2 + \text{O}_2$
correct products
balanced equation

[1]

[1] [4]

[Total: 17 max. 16]

5. (a) $1s^2$ $2s^2 2p^6$ $3s^2 3p^3$ [1]

(b) 5 or V [1]

(c) (i) $3\text{NaOH} + \text{H}_3\text{PO}_4 \longrightarrow \text{Na}_3\text{PO}_4 + 3\text{H}_2\text{O}$ [1]

(ii) $(50 \times 0.5) / 1000 = 0.025$ (moles) [1]

(iii) conseq. on (i) $3 \times 0.025 = 0.075$ (moles) [1]

(d) (i) $\text{P}_4\text{S}_3 + 8\text{O}_2 \longrightarrow \text{P}_4\text{O}_{10} + 3\text{SO}_2$ balanced = 2 marks
(or $2\text{P}_2\text{O}_5$)

OR $+ 2 \longrightarrow \text{P}_4\text{O}_6 + 3\text{SO}_2$ unbalanced = 1 mark
(or $2\text{P}_2\text{O}_3$)

[2]

(ii) $\text{P}_4\text{O}_{10} + 6\text{H}_2\text{O} \longrightarrow 4 \text{H}_3\text{PO}_4$ [1]

OR $\text{P}_4\text{O}_6 + 6\text{H}_2\text{O} \longrightarrow 4\text{H}_3\text{PO}_3$

$\text{SO}_2 + \text{H}_2\text{O} \longrightarrow \text{H}_2\text{SO}_3$ [1]

(if SO_3 then e.c.f.)

Total = [9]

CHEMISTRY ONLINE
— TUITION —