A-Level Chemistry

Electron Configuration

Mark Scheme

Time available: 58 minutes
Marks available: 52 marks

www.accesstuition.com

1. (a) Aluminium / Al

*Allow **M2**/**M3** if a Group 3 element is given*

1

(Outer) electron in (3)<u>p</u> orbital / sub-shell (level)

Not energy level

1

(3p) higher in energy / slightly more shielded (than 3s) / slightly further away (than 3s)

1

or

OR

Sulfur / S

*Allow **M2**/**M3** if a Group 6 element is given*

1

(Outer) electrons in (3)p orbital begin to <u>pair</u>

Do not allow just p^4 vs p^3

1

Repel

1

(b) $Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$

State symbols essential.

Allow

$Na^{2+}(g) + e^- \rightarrow Na^{3+}(g) + 2\ e^-$

1

(c) **M1** Phosphorus / P

Mark independently

M2 large jump in ionisation energy for the 6th ionisation energy

Large jump after the 5 e^- is removed / when the 6th e^- is removed

M3 This is when the electron is being removed from the 2nd (principle) energy level / from a lower energy level / from a lower shell / from 2p / from an energy level that is closer to the nucleus

3

[7]

2. (a) Cross at 1580

Allow a cross drawn for Si that is between the values for Mg and Al

1

(b) **M1** Na

1

M2 $Na^+(g) \rightarrow Na^{2+}(g) + e^-$

***M2** Allow $Q^+(g) \rightarrow Q^{2+}(g) + e^-$*

State symbols essential

Allow correct equation consequential on their element

1

(c) The number of protons increases OR nuclear charge increases

1

Shielding is similar/same OR electrons are added to the same shell

Allow same number of shells

1

(d) Chlorine/Cl

1

(e) $4P + 5O_2 \rightarrow P_4O_{10}$ OR $P_4 + 5O_2 \rightarrow P_4O_{10}$

Allow multiples

Ignore state symbols

Do not allow equations with P_2O_5

1

[7]

3. (a) [Kr] $5s^2\ 4d^{10}5p^5$

1

(b) This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.

Level 3

All stages are covered and the explanation of each stage is correct and complete.

Answer communicates the whole explanation coherently and shows a logical progression from stage 1 to stage 2 and then stage 3.

5-6 marks

Level 2

All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages are covered and the explanations are generally correct and virtually complete.

Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be out of order and incomplete.

3-4 marks

Level 1
Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies, **OR** only one stage is covered but the explanation is generally correct and virtually complete.

Answer includes some isolated statements, but these are not presented in a logical order or show confused reasoning.

1-2 marks

Level 0
Insufficient correct chemistry to warrant a mark.

0 marks

Indicative Chemistry content

Stage 1

I_2 is molecular.

HI is molecular.

Stage 2

IMF hold the molecules together.

There are weak IMF forces hence the melting point is low in both substances.

I_2 bigger molecule than HI so I_2 has more electrons.

Stage 3

Therefore stronger van der Waals between molecules in I_2 that need more energy to break causing the melting point to be higher.

HI also shows permanent dipole-dipole attraction between molecules but these forces are less than the vdW forces in iodine.

6

(c) No delocalised electrons or ions

1

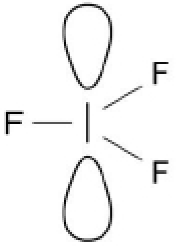
(d) $\frac{1}{2}H_2 + \frac{1}{2}I_2 \longrightarrow HI$

Allow multiples

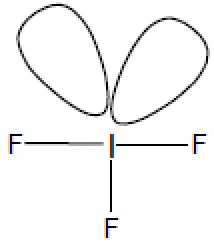
1

(e) NH_4I_3

1

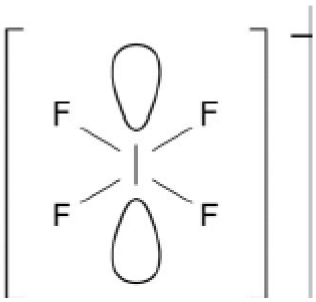
(f) 

or



Allow any shape with 3 bond pairs and 2 lone pairs

1



Allow any shape with 4 bond pairs and 2 lone pairs (e.g. lone pairs in equatorial positions)

1

(g) +5

1

+7

1

[14]

4. (a) **Y**

1

(b) **X**

1

(c) Jump in trend of ionisation energies after removal of fifth electron

Fits with an element with 5 outer electrons ($4s^23d^3$) like V

1

(d) Explanation: Two different colours of solution are observed

1

Because each colour is due to vanadium in a different oxidation state

1

(e) **Stage 1:** mole calculations in either order

Moles of vanadium = 50.0 × 0.800 / 1000 = 4.00×10^{-2}

Extended response

Maximum of 5 marks for answers which do not show a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.

1

Moles of SO_2 = pV / RT = $(98\,000 \times 506 \times 10^{-6}) / (8.31 \times 293)$

= 2.04×10^{-2}

1

Stage 2: moles of electrons added to NH_4VO_3

When SO_2 (sulfur(IV) oxide) acts as a reducing agent, it is oxidised to sulfate(VI) ions so this is a two electron change

1

Moles of electrons released when SO_2 is oxidised = $2.04 \times 10^{-2} \times 2$

= 4.08×10^{-2}

1

Stage 3: conclusion

But in NH_4VO_3 vanadium is in oxidation state 5

1

4.00×10^{-2} mol vanadium has gained 4.08×10^{-2} mol of electrons therefore 1 mol vanadium has gained 4.08×10^{-2} / 4.00 × 10 – 2 = 1 mol of electrons to the nearest integer, so new oxidation state is 5 – 1 = 4

1

[11]

5. (a) General increase

If not increase then CE

1

Greater nuclear charge / more protons

1

Same shielding / electrons added to same shell

Allow similar

1

Stronger <u>attraction</u> (from nucleus) for <u>outer electron(s)</u>

Allow electron in outer shell

1

(b) Aluminium / Al (lower than Mg)

CE if not Al or S

1

(Outer) electron in (3)p orbital / sub-shell (level)

If 2p or 4p orbital lose M2 and M3

1

(3p) higher in energy

Allow more shielded or weaker nuclear attraction

M3 is dependent on M2

1

or
Sulfur / S (lower than P)
(Outer) electrons in (3)p orbital begin to pair
Repel

If 2p or 4p orbital lose M2 and M3

Allow 2 electrons in (3)p

M3 is dependent on M2

(c) Sulfur / S

CE if not S

1

Large jump after 6^{th} or between 6^{th} and 7^{th}

Do not allow M2 if atom/ion is removed

1

(d) Silicon

CE if not Si

1

Giant covalent structure / macromolecule

1

Covalent (bonds)

Giant covalent scores M2 and M3

1

Many / strong (covalent bonds) or
(covalent bonds) need lots of energy to break

CE for M2-M4 if molecules / metallic / ionic / IMFs mentioned

1

[13]