1. Xe has a bigger atomic radius **OR** Xe has more shells ✓

> ***ALLOW** Xe has more energy levels*
> ***ALLOW** Xe has electrons in higher energy level*
> ***ALLOW** Xe has electrons further from nucleus*
> ***IGNORE** Xe has more orbitals **OR** more sub-shells*
> ***DO NOT ALLOW** 'different shell' or 'new shell'*

Xe has **more** shielding ✓

> ***ALLOW More** screening*
> *There must be a clear comparison ie **more** shielding **OR***
> ***increased** shielding.*
> *i.e. **DO NOT ALLOW** Xe 'has shielding'*
> ***ALLOW** Xe has **more** electron repulsion from inner shells*

The nuclear attraction decreases
OR Outermost electrons of Xe experience less attraction (to nucleus)
OR Increased shielding / distance outweighs the increased nuclear charge ✓
ORA throughout

> ***ALLOW** Xe has less nuclear pull*
> ***IGNORE** Xe has less effective nuclear charge*
> ***DO NOT ALLOW** nuclear charge for nuclear attraction*

[3]

2. $3d^{10} 4s^2 4p^5$ ✓

> ***ALLOW** $4s^2 3d^{10} 4p^5$*
> ***ALLOW** subscripts or $3D^{10}$*
> ***ALLOW** answers with $1s^2 2s^2 2p^6 3s^2 3p^6$ appearing twice*
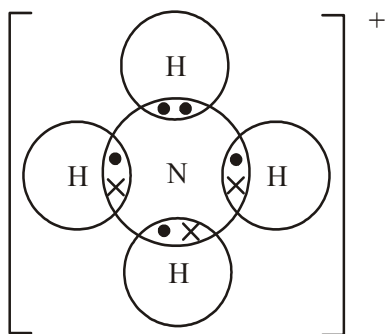
[1]

3. (i) $1s^2 2s^2 2p^6 3s^2 3p^6$ ✓

> ***ALLOW** subscripts*

1

(ii)

'Dot-and-cross' diagram to show four shared pairs of
electrons one of which is a dative covalent bond (which
must consist of the same symbols) ✓

> *IGNORE inner shells*
> *IGNORE '+' sign **BUT DO NOT ALLOW** a '−' sign.*
> *Brackets and circles not required*

1

(iii)   tetrahedral ✓

109.5° ✓

> ***ALLOW** 109 – 110°*

2

(iv)   ions **OR** electrons cannot move in a solid ✓

ions can move **OR** are mobile in solution ✓

> ***ALLOW** ions can move in liquid*
> ***DO NOT ALLOW** ions can move when molten*
> ***ALLOW** 1 mark for:*
> *'Ions can only move in solution'*

2

[6]

4.   the energy required to remove one electron ✓ from each
atom in one mole ✓ of gaseous atoms ✓

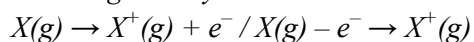> ***ALLOW** 3 marks for:*
> *the energy required to remove one mole of electrons ✓*
> *from one mole of atoms ✓*
> *atoms in the gaseous state ✓*
>
> *If no definition, **ALLOW** one mark for the equation below,*
> *including state symbols.*
> $X(g) \rightarrow X^+(g) + e^- / X(g) - e^- \rightarrow X^+(g)$
> ***ALLOW** e for electron*
> ***IGNORE** state symbol for electron*

[3]

5. (i) $O^+(g) \rightarrow O^{2+}(g) + e^-$ ✔

                     *answer **must have** state symbols*
                     ***ALLOW** e for electron*
                     ***ALLOW** $O^+(g) - e^- \rightarrow O^{2+}(g)$*
                     ***DO NOT ALLOW** $O^+(g) + e^- \rightarrow O^{2+}(g) + 2e^-$*
                     ***IGNORE** state symbol for electron*

                                                                1

      (ii)   the O^+ ion, is smaller than the O atom
            OR
            the electron repulsion/shielding is smaller
            OR
            the proton : electron ratio in the 2+ ion is greater than in
            the 1+ ion ✔

                     ***ALLOW** the outer electrons in an O^+ ion are closer to the*
                     nucleus than an O atom
                     ***DO NOT ALLOW** 'removed from next shell down'*

                                                                1

                                                                        [2]

6. (i)   number of protons (in the nucleus) ✔

                     ***ALLOW** proton number*
                     ***ALLOW** number of protons in an atom*
                     ***IGNORE** reference to electrons*

                                                                 1

      (ii) $(1s^2)2s^22p^63s^23p^63d^24s^2$ ✔

                     ***ALLOW** $1s^2$ written twice*
                     ***ALLOW** subscripts*
                     ***ALLOW** $4s^2$ before $3d^{2+}$*

                                                                    1

     (iii)   Mn / manganese **and** d ✔
                     ***ALLOW** D*

                                                                  1

                                                                        [3]

7. (i)   atoms of the same element with different numbers of
              neutrons/different masses **(1)**   1

   (ii) ^{79}Br 35 protons, 44 neutrons, 35 electrons **(1)**
           ^{81}Br 35 protons, 46 neutrons, 35 electrons **(1)**   2

   (iii) $(1s^2)2s^22p^63s^23p^63d^{10}4s^24p^5$ **(1)**   1

                                                                                           [4]

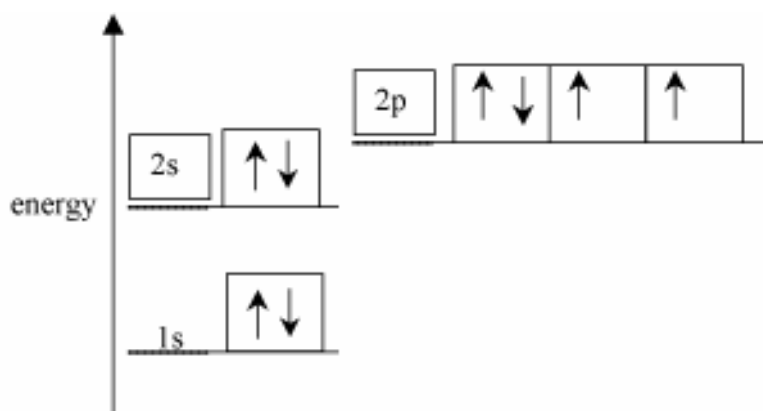**8.** (a)   2

1, 2 or 3 p orbitals are OK

   (b)   d orbital 2 ✓
          p sub-shell 6 ✓
          3rd shell 18 ✓   3

   (i)

   (ii)   2
   2s and 2p labels ✓ Ignore any superscripted numbers.
          8 electrons in correct levels with arrows correctly shown ✓

                                                                                           [7]

9. (i) Energy change when each atom in 1 mole ✓
of gaseous atoms ✓
loses an electron ✓ (to form 1 mole of gaseous 1+ ions).   3

(ii) $O^{2+}(g) \rightarrow O^{3+}(g) + e^-$ ✓✓   2
1 mark for correct species; 1 mark for state symbols
No charge required on electron.
Ignore (g) on e

(iii) Large difference between 6th and 7th IEs ✓   2
marking a different shell (closer to nucleus) ✓
       allow 'inner shells'/new shell/full shell/first shell
       marking points independent.
       ***not** sub-shell or orbital*

                                                                                        [7]

10. (i)
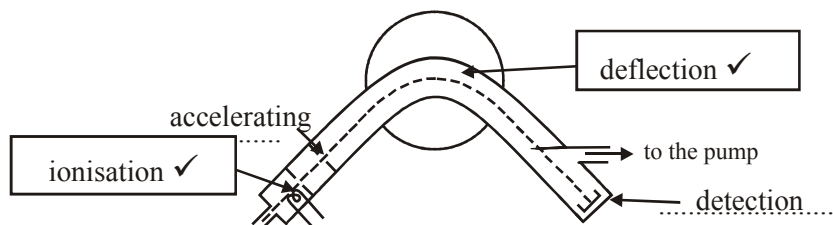
	protons	neutrons	electrons		
^{25}Mg	12	13	12	✓	
^{26}Mg	12	14	12	✓	2

(ii) $1s^2 2s^2 2p^6 3s^2$ ✓

$24 \times 78.60/100 + 25 \times 10.11/100 + 26 \times 11.29/100$ ✓   1

(iii) = 24.33 ✓ (calc value: 24.3269. This scores one mark)   2
24.32 with no working, award 1 mark only.
24.3 with no working, no marks (Periodic Table value)

                                                                                        [5]

11. (a) Energy change when **each atom in 1 mole** ✓
of gaseous **atoms** ✓
loses an electron ✓ (to form 1 mole of gaseous 1+ ions).   3

(b)   From Li → N, ionisation energy increases✓
number of protons/nuclear charge increases✓
nuclear attraction increases / shell drawn in by increased
nuclear charge/ atomic radius decreases✓
across period, electrons added to same shell✓
        Not same subshell

From Be → B, ionisation energy decreases✓
for B, electron is removed from a p sub-shell/p
orbital/different sub-shell✓
which has a higher energy✓   7
        *watch for distinction between nuclear **attraction** and*
        *nuclear **charge** in candidates' scripts.*
        Also watch for confusion between shell and subshell.

Al✓
Sharp rise in successive ionisation energy between 3rd and
4th IE✓
marking a change to a new or different shell / there are 3
electrons in the outer shell✓   3
        *mention **of** 'orbital' or 'sub-shell cancels 'shell mark' Each*
        marking point for Al is independent

QoWC: links together two pieces of information
            correctly within two of the sections below:
            1. General trend across period
            2. Be to B
            Successive ionisation energies✓

                                                [13]

12. (i) $Ca^+(g) \rightarrow Ca^{2+}(g) + e^-$
Equation with correct charges and 1 electron lost ✓
state symbols ✓
'−' not required on 'e'   2

(ii)   same number of protons or same nuclear charge attracting
less electrons/
electron removed from an ion/
less electron-electron repulsion (**not** less shielding)/
ion is smaller✓   1

(iii)   atomic radii of Sr > atomic radii of Ca/
Sr has electrons in shell further from nucleus than Ca/
Sr has electrons in a higher energy level/
Sr has more shells ✓
Therefore less attraction ✓
Sr has **more** shielding than Ca ✓
(**'more'** is essential)   3

increased nuclear charge is outweighed / despite increased nuclear
charge …..by at least one of the factors above ✓

                                              [6]

13. $1s^2 2s^2 2p^2$ ✓

[1]

14. (i) Energy change when each atom in 1 mole ✓
of gaseous atoms ✓
loses an electron ✓ (to form 1 mole of gaseous 1+ ions). 3

(ii) increasing nuclear charge/number of protons ✓
electrons experience greater attraction or *pull* / atomic
radius decreases / electrons added to same shell /same or
similar shielding ✓ 2

(iii) In B, electron being removed is at a higher energy /
In Be, electron being removed is at a lower energy ✓

An s electron is lost in Be AND a p electron is lost in B ✓ 2

[7]

15. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$ ✓

[1]

16. (i) First ✓ ionisation (energy) ✓ 2

$Ra(g) \rightarrow Ra^+(g) + e^-$ ✓✓
1 mark for equation
1 mark for state symbols
'−' not required on 'e' 2

(ii) atomic radii of Ra > atomic radii of Ca/
Ra has electrons in shell further from nucleus than Ca/
Ra has more shells ✓

Ra has **more** shielding than Ca ✓
∴ '***more***' is essential

Ra electron held less tightly/less attraction on electron ✓ 3

[7]

17. (i) $1s^2 2s^2 2p^6 3s^2 3p^6$..........$3d^{10} 4s^2 4p^5$ ✓✓ 2

Award 1 mark for p^5.

(ii) Highest energy sub-shell/sub-shell/being filled is the p
sub-shell/outer electrons are in a p (sub-shell/orbital/shell) ✓ 1

[3]

18. (a) Energy change when each atom in 1 mole ✓

of gaseous atoms ✓   3

loses an electron ✓ (to form 1 mole of gaseous 1+ ions).

(b) increasing nuclear charge/number of protons ✓

electrons experience greater attraction or *pull*/atomic
radius decreases/electrons added to same shell/same or
similar shielding ✓   2

[5]