

F321: Atoms, Bonds and Groups

Periodicity – Mark Scheme

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. (i) Potassium **AND** argon ✓

ALLOW K and Ar

1

- (ii) They are arranged in increasing atomic number

OR

Neither would show properties **OR** trends of rest of group

OR

Neither would show properties **OR** trends of rest of period

OR

They are arranged by electron configuration ✓

ALLOW any correct property difference
e.g. This would place a reactive metal in the same group as noble gases
ALLOW they do not fit in with the rest of the group

1

[2]

3. (a) (i) Magnesium ions have a greater charge ✓

Magnesium has more
(delocalised **OR** outer) **electrons** ✓

Magnesium has greater attraction between **ions** and
electrons OR has stronger **metallic** bonds ✓

USE annotations with ticks, crosses, ecf, etc for this part.

ALLOW REVERSE ARGUMENT

e.g. sodium ions have a smaller charge

ALLOW Mg^{2+} / Mg ion / Na ion / Na^+ ion

ALLOW 'charge density' as alternative to 'charge'

ALLOW REVERSE ARGUMENT

e.g. sodium has fewer electrons

ALLOW REVERSE ARGUMENT

*e.g. sodium has less attractions between **ions** and
electrons*

OR has weaker **metallic** bonds ✓

3

(ii) Cl_2 **OR** S_8 has intermolecular **OR** van der Waals' forces ✓

S_8 has stronger intermolecular forces **OR** van der
Waals' forces than Cl_2

OR

S_8 has more electrons ✓

ALLOW REVERSE ARGUMENT *ie Cl_2 has weaker
intermolecular forces **OR** van der Waals' forces*

DO NOT ALLOW comparison involving covalent bonds

ALLOW REVERSE ARGUMENT

Cl_2 has fewer electrons

2

(b) nuclear charge increases/ protons increase ✓

electrons added to the same shell

OR

screening **OR** shielding remains the same ✓

greater attraction **OR** greater pull ✓

USE annotations with ticks, crosses, ecf, etc for this part.

*Nuclear **OR** proton(s) **OR** nucleus spelt correctly
ONCE*

IGNORE 'atomic number increases'

IGNORE 'nucleus gets bigger'

'charge increases' is not sufficient

*ALLOW 'effective nuclear charge increases' **OR***

'shielded nuclear charge increases'

IGNORE reference to atomic radius staying the same

ALLOW shielding is similar

DO NOT ALLOW extra shielding

*A comparison **must** be included:*

i.e. 'greater pull', 'more pull', 'held more tightly';

3

[8]

4. (i) outer electrons closer to nucleus **OR** radii decreases ✓

nuclear charge increases

OR protons increase ✓

electrons added to the same shell

OR

screening **OR** shielding remains the same ✓

IGNORE 'atomic number increases'

IGNORE 'nucleus gets bigger'

'charge increases' is not sufficient

*ALLOW 'effective nuclear charge increases' **OR***

'shielded nuclear charge increases'

ALLOW shielding is similar

3

- (ii) atomic radii increase **OR**
 there are more shells ✓
 there is **more** shielding **OR more** screening ✓
 the nuclear attraction decreases
OR
 Increased shielding / distance outweigh the increased
 nuclear charge ✓

ALLOW electrons in higher energy level

ALLOW electrons are further from the nucleus

***DO NOT ALLOW** more orbitals **OR** more sub-shells*

***DO NOT ALLOW** different shell or new shell*

*There must be a clear comparison: e.g. 'more shielding',
 'increased shielding'. i.e. **DO NOT ALLOW** just 'shielding'.*

ALLOW 'more electron repulsion from inner shells'

*Nuclear **OR** proton(s) **OR** nucleus spelt correctly **ONCE***

ALLOW 'nuclear pull'

***IGNORE** any reference to 'effective nuclear charge'*

3

[6]

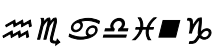
- | | | | |
|----|-------|--------|---|
| 5. | (i) | S (1) | 1 |
| | (ii) | Al (1) | 1 |
| | (iii) | B (1) | 1 |
| | (iv) | Ca (1) | 1 |
| | (v) | K (1) | 1 |
| | (vi) | K (1) | 1 |

[6]

indent3;mark;Default;header;TOCI;Answer;Part

lines;question(a)(i);indent2;indent1(a);BoxL;Bottom;heading

1;heading 2;heading 3;heading 4;heading 5;heading 6;heading

7;  heading

9;ex;ex2;graph;Hyperlink;right;Box;BoxR;annotation reference;✓

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6.

- (i) atomic radii decrease /s
number of protons in the nucleus increases (1) 3
nuclear attraction increases (1) 3
- (ii) $\text{Na}^{2+}(\text{g}) \rightarrow \text{Na}^{3+}(\text{g}) + \text{e}^-$: equation and state symbols (1) 1
- (iii) large jump (in energy) between the 4th and 5th ionisation energies (1)
four electrons in outer shell so element is Si (1) 2

[6]

7. atomic radii of Rb > atomic radii of elements above/
Rb has electrons in shell further from nucleus /
Rb has more shells ✓

Rb has **more** shielding ✓ ('*more*' is essential)

(increased) nuclear charge is outweighed /
despite increased nuclear chargeby at least one of the
factors above/
less attraction/ held less tightly ✓

[3]

8. (i) They have different numbers of protons/
Ba has one more proton/Ba has 56 p⁺; Cs has 55 p⁺ ✓ 1
(ignore electrons: any mention of 'neutrons' is wrong)
- (ii) s ✓ 1
- (iii) Cs to Ba: nuclear charge increases/more protons ✓
electrons are in: the same shell/sub-shell/orbital
/similar shielding/same shielding ✓ 3
attraction increases/pull increases ✓ORA
- (iv) smaller ✓ 2
shell has been lost/less shielding/less electron
repulsion/proton : electron ratio larger ✓
mark separately

[7]

9. (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]

10.	High boiling point or difficult to break linked to strong bonds in the right context within Li or C ✓	1	
	Li conducts by delocalised/free/mobile electrons ✓ structure: giant ✓ metallic ✓ or '+ ions with a sea of electrons' for giant mark	3	
	C conducts by delocalised/free/mobile electrons ✓ structure: giant ✓ covalent with layers ✓	4	
	N No mobile charge carriers/electrons/ions to conduct electricity ✓ simple molecular structure/made of N ₂ molecules ✓ low boiling point or easily broken due to intermolecular forces/ van der Waals' forces ✓	3	
	QWC: At least 2 complete sentences in which the meaning is clear. ✓	1	[12]
11.	(i) O ✓	1	
	(ii) Al ✓	1	
	(iii) P ✓	1	
	(iv) C/Si ✓	1	
	(v) N/P ✓	1	
	(vi) Mg ✓	1	
	(vii) Na ✓	1	
	(viii) Si ✓	1	[8]
12.	(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 <i>pull</i> / 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]

13. (i) First ✓ ionisation (energy) ✓ 2
 $\text{Ra(g)} \rightarrow \text{Ra}^+(\text{g}) + \text{e}^-$ ✓✓
 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]
14. N has less protons than O (ora) ✓
 electrons are in same shell
 /have same or similar shielding ✓
 weaker nuclear attraction in N (ora) ✓
 shell drawn in less by nuclear charge in N (ora) ✓
 watch for distinction between nuclear **attraction** and nuclear **charge** in candidates’ scripts.
 QoWC: links together two statements in at least two of the sections (a)(ii), (b) and (c) ✓
- [4]
15. (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]

16. (From 2 →10 →18 / down group)

1st ionisation energies decrease/easier to remove electrons ✓
electron is further from nucleus/ atomic radius increases/

electron in a different shell/ atoms increase in size ✓
(*not sub-shell or orbital*)

electron experiences **more** shielding ✓
(*more is essential here*)

distance and shielding outweigh the increased nuclear charge ✓
NOT: attraction/pull; effective nuclear charge

[4]