O Level Pure Chemistry Structured

Periodic Table Test 1.0

Q1

Ionisation energy is the amount of energy needed to remove an electron from an atom or ion. It is usually measured in kilojoules (kJ). The closer the electron to be removed is to the nucleus, the higher the ionisation energy.

The ionisation energies for sodium are listed in Table 7.1.

Table 7.1

Ionisation energy number	Energy needed (kJ)
1st	495.8
2nd	4562
3rd	6910.3
4th	9543
5th	13354
6th	16613
7th	20117
8th	25496
9th	28932
10th	141362
11th	159075

Source: https://www.webelements.com/sodium/atoms.html

Typically, the *n*th ionisation of an atom or ion (**X**) can be expressed as:

$$X^{n-1} \rightarrow X^{n+} + e$$

where *e* represents electron removed

Thus for the 1st ionisation of sodium:

$Na \rightarrow Na^{+} + e$ energy needed = 495.8 kJ

2nd ionisation of sodium:

$Na^{+} \rightarrow Na^{2+} + e$ energy needed = 4562 kJ

3rd ionisation of sodium:

$Na^{2+} \rightarrow Na^{3+} + e$ energy needed = 6910.3 kJ

(a) The electronic configuration for a sodium atom may be written as 2,8,1.

State, in a similar way, the electronic configuration for a

- Na^{+} ion ……………………………………
- Na^{2+} ion …………………………………… [1]

(b) Based on your understanding of ionisation energy and electronic configurations, suggest why the value for the 2nd ionisation energy of sodium is much higher than the 1st.

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[2]

(c) **(i)** Write an expression for the **10th** ionisation of sodium, in a manner similar to the first three ionisations of sodium as shown in the given data.

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[1]

(ii) By considering the location of the electron to be removed, explain why the value for the 10th ionisation energy for sodium is much higher than the 2nd to 9th ionisation energies.

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[2]

Table 6.2 lists the 1st ionisation energy (in kJ) for the first twenty elements in the Periodic Table.

Table 6.2

H 1312							**He** 2372
Li 520	**Be** 900	**B** 801	**C** 1087	**N** 1402	**O** 1314	**F** 1681	**Ne** 2081
Na 496	**Mg** 738	***Al*** 578	**Si** 787	**P** 1012	**S** 1000	***Cl*** 1251	**Ar** 1521
K 419	**Ca** 590						

Source: http://www.sciencegeek.net/tables/IonisationNRG.pdf

(d) Describe the trends in the 1st ionisation energy **across a period** and **down a group** in the Periodic Table.

(i) Across a period:

....

(ii) Down a group:

....

[2]

(e) Explain why the 1st ionisation energy is generally higher for non-metals than metals.

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[2]

[10 marks]

Q2

The diagram below shows part of the Periodic Table.

				H						
Li	Be					B	C	N	O	F
Na	Mg					Al	Si	P	S	Cl
K	Ca				Zn	Ga	Ge	As	Se	Br
Rb	Sr									I

Answer these questions using only the elements shown in the diagram. Each element can be used once, more than once or not at all.

(a) Which two elements form the gas released when aqueous sodium nitrate is warmed with aqueous sodium hydroxide and aluminium foil?

.... [1]

(b) Which two elements in Period 3 form an ionic compound with the formula of the type $\mathbf{Y_2Z}$?

.... [1]

(c) Which two elements form the compound with a giant molecular structure?

.... [1]

(d) Which element can be used as a reducing agent in the extraction of iron from iron(III) oxide?

.... [1]

(e) Which two elements form a solution used to test for an oxidising agent?

.... [1]

[Total: 5]

Q3

Use the information in the table below to answer the questions.

element	formula(e) of oxide(s)	density of element at r.t.p (g/cm^3)	volume of 1 mole of atoms at r.t.p (cm^3)
A	A_2O, A_2O_2	0.00008	12 000
B	None formed	0.00346	24 000
C	C_2O	0.53	13.20
D	D_2O	0.97	23.71
E	EO_2, EO_3	2.07	15.46
F	F_2O_3	3.00	15.00
G	GO, G_2O_3	7.86	7.11

(r.t.p refers to room temperature and pressure)

(a) Which two elements are in the same group of the Periodic Table. Explain your answer.

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.... [2]

(b) Which element could be argon? Explain your answer.

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.... [2]

(c) Using information in the third and fourth columns, calculate the mass of 1 mole of **F** and identify **F**.

[2]

(d) Write down two observations you would expect to see when element **G** is added to dilute nitric acid.

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.... [2]

[Total: 8 marks]

Q4

The first ionisation energy of elements is the energy required to remove one mole of electrons from one mole of gaseous atoms to form one mole of gaseous ions with a charge of +1.

This can be represented by the equation:

$$Na(g) \rightarrow Na^{+}(g) + e^{-} \qquad \Delta H = +494\ kJ/mol$$

The second ionisation energy of elements is the energy required to remove one mole of electrons from one mole of gaseous ions with a charge of +1 to form one mole of gaseous ions with a charge of +2.

This can be represented by the equation:

$$Na^{+}(g) \rightarrow Na^{2+}(g) + e^{-} \qquad \Delta H = +4562\ kJ/mol$$

Hence, the energy required to remove 2 moles of electrons from 1 mole of gaseous sodium atoms is 494 + 4562 = 5056 kJ/mol.

Table 9.1 shows the first and second ionisation energy for Group I elements, while Table 9.2 shows the first and second ionisation energy for Group II elements.

Table 9.1

element	first ionisation energy/ $kJ\ mol^{-1}$	second ionisation energy/ $kJ\ mol^{-1}$
lithium	520	7298
sodium	496	4562
potassium	419	3052
rubidium	403	2633
caesium	376	2234

Table 9.2

element	first ionisation energy/ $kJ\ mol^{-1}$	second ionisation energy/ $kJ\ mol^{-1}$
beryllium	900	1757
magnesium	737	1451
calcium	590	1145
strontium	550	1064
barium	503	965

(a) Describe and explain the trend in ionisation energy down Group I and II.

....

....

....

....

....

....[3]

(b) **(i)** Write the electronic configurations for sodium and magnesium atoms.

Na: ....

Mg: ....[1]

(ii) Using your answer in **(b)(i)**, suggest why the difference between the first and second ionisation energy is significantly higher for sodium than magnesium.

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....[2]

(c) Write a balanced equation, including state symbols, for the third ionisation energy of sodium.

....[1]

(d) Calculate the energy required for 12 g of magnesium atoms to form Mg^{2+} ions.

[3]

[Total: 10]

Q5

Read the information about elements in Group VII of the Periodic Table.

Halogens and its properties

Fluorine, chlorine, bromine, iodine and astatine are elements that are found in Group VII of the Periodic Table. They are reactive non-metals which exists as diatomic molecules. Some trends that can be observed as we go down Group VII are atomic radius and ionic radius. Table 1.1 gives the atomic radii and the ionic radii of halogens.

Table 1.1

halogen	atomic radius/ nm	ionic (X^-) radius/ nm
F	0.071	0.133
C*l*	0.099	0.181
Br	0.114	0.196
I	0.133	0.220
At	0.150	-

Electron affinity is a measure of the attraction between the incoming electron and the nucleus. The first electron affinity is the energy released when 1 mole of gaseous atoms each acquire an electron to form 1 mole of gaseous ions. For example, in this reaction,

$X(g) + e^- \rightarrow X^-(g)$

The first electron affinity is the energy released per mole of X when this change occurs. By convention, the negative sign shows a release of energy.

Table 1.2 gives the first electron affinities of Group 7 elements.

Table 1.2

halogen	first electron affinity (kJ/mol)
F	- 328
C*l*	- 349
Br	- 324
I	- 295
At	- 270

Halogens also react with hydrogen to form hydrogen halides.

$$H_2 + X_2 \rightarrow 2HX$$

Table 1.3 gives the bond energies of various H – X bonds.

Table 1.3

bond	bond energy (kJ / mol)
H – F	562
H – C*l*	431
H – Br	366
H – I	299

(a) State the general trend observed in the first electron affinities going down Group VII.

.... [1]

(b) Suggest why the atomic size of the atoms increases down the group and hence use this knowledge to explain the pattern described in **(a)**.

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....

.... [2]

(c) Both chlorine and fluorine are gases at room temperature and pressure.
Using the information in Table 1.1, state and explain which gas is likely to have a lower boiling point.

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.... [3]

(d) Two students discuss the information provided.

Student 1: ‘I think the atomic size of the halogen attached to H is linked to the strength of the H−X bond.’

Student 2: ‘I think the strength of the H−X bond is due to its ionic (X^-) radii.’

Does the information in the data given support the ideas of the students?
Explain your reasoning.

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.... [2]

(e) All hydrogen halides dissolve in water to form acids.
Use Table 1.3 to predict the trend in the acid strength of the hydrogen halides.
Explain your answer.

....

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.... [2]

[Total: 10 marks]

Answers

Periodic Table Test 1.0

Q1

(a) Na^+ ion : 2, 8 [½]

Na^{2+} ion : 2, 7 [½]

(b) 1st ionisation energy is the energy required for a sodium atom to lose 1 valence electron, and obtaining a stable octet / stable electronic structure. [1]

2nd ionisation energy is the energy required to remove an electron from the stable octet. This **disrupts the stable electronic configuration**. Hence more energy is needed. [1]

(c) (i) $Na^{9+} \rightarrow Na^{10+} + e$ [1]

(ii) The 10th ionisation energy involves the removal of an electron from the 1st shell

The 2nd to 9th ionisation energy involves removing electrons from the 2nd shell.

Electrons in 1st shell are <u>closer to</u> the positively charged <u>nucleus</u> than those in the 2nd shell;

Attraction (between electron and nucleus) is stronger;

A larger amount of energy is needed to remove that electron (in the 1st shell).

[2]

Award 1m for describing removal of electrons from 1st / 2nd shell.

Award 1m for stating being closer to nucleus requires larger amount of energy.

Allow 1m should student describe shielding effect instead of proximity to nucleus.

(d) (i) Increases across the period [1]

(ii) Decreases down the group [1]

(e) Metals tend to lose electrons (to gain stability with full most outer shell) and form positively charged ions (or cations);

non-metals tend to gain electrons and form negatively charged ions (or anions).

Removing electrons from an atom of non-metal makes its electronic structure less stable.

[2]

[10 marks]

Q2

(a)	N & H	[1]
(b)	Na & S	[1]
(c)	Si & C or Si & O	[1]
(d)	C	[1]
(e)	K & I or Cl or Br or H & O	[1]

Q3

(a)	C and D. Both elements form oxides of the same chemical formulae, C_2O and D_2O. This shows that the elements formed ions that have a charge of +1 and they both belong in Group I of the Periodic Table as they have the same number of valence electron.	1 1
(b)	B. Its volume of 1 mole of atoms is 24 000 cm^3, indicating that B is monoatomic. (Reject: it does not form any oxide or reacts with oxygen)	1 1
(c)	Mass of 1 mole of F = 3 x 15 = 45 g F is scandium.	1 1
(d)	Effervescence / Bubbles is seen, pale green solution is formed.	1 1

Q4

(a)	Ionisation energy decreases down Group I and II; Down the group, electron to be removed/valence electron is found further away from the nucleus; Less energy is needed to overcome electrostatic forces of attraction between nucleus and electron to be removed/ electrostatic forces of attraction between nucleus and electron is weakened; A: forces of attraction R: bonds for forces of attraction, break for overcome, less electrostatic forces of attraction, electrostatic forces of attraction decreases, nucleon for nucleus, neutron for nucleus	[1] [1] [1]
(b)(i)	Sodium: 2,8,1; Magnesium: 2,8,2;	[1]
(b)(ii)	The two electrons to be removed for sodium are third and second electron shells; Those of magnesium are from the third electron shell; OR Removing the second electron will disrupt the stable electronic configuration of sodium ion Removing the second electron will give magnesium ion the stable electronic configuration;	[1] [1] [1] [1]

	OR More energy needed to remove second electron from sodium once stable/full/octet configuration is attained; Less energy needed to remove second electron of magnesium as it will achieve the stable/full/octet configuration;	 [1] [1]
(c)	$Na^{2+}(g) \rightarrow Na^{3+}(g) + e^-$; R: missing/wrong state symbol(s)	[1]
(d)	Number of moles in 12 g of Mg = 12/24 = 0.5 mol Energy required to remove 2 electrons from 1 mol of Mg = 737 + 1451 = 2188 kJ; Energy required to form 12 g of Mg^{2+} ions = 2188 x 0.5 = 1094 kJ; R: wrong unit	[1] [1] [1]

Q5

B1(a)	Decreases down the group.	
(b)	Atomic radius **increases** as the number of **electron shells increases** down the group. As the electron shells increase, the **distance** between the **nucleus** and the **incoming electron increases.** Therefore, the electrostatic forces of **attraction between the nucleus and the incoming electron decreases**, thus the amount of energy released decreases when the atom takes in an electron.	**1** **1** **1**
(c)	Fluorine has lower boiling point. Fluorine molecules are **smaller in size** than that of chlorine/ lower relative molecular mass than that of chlorine The **intermolecular forces of attraction** between fluorine molecules are weaker than that of chlorine. **Less energ**y is needed to overcome the weaker intermolecular forces of attraction.	**1** **1** **1**
(d)	Student 1 is **supported**. The **smaller** the halogen, the **stronger** the H – X bond. Student 2 is **not supported** as HX is a **covalent** compound and there are no halogen ions in HX. Therefore, the ionic radii is not relevant to the strength of the H – X bond.	**1** **1**
(e)	Acid strength **increases** down the group. The **smaller** the bond energy, the **easier** it is for the acid to **ionize** to form H^+ ions.	**1** **1**