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CHEMISTRY

Physical Chemistry

Level & Board	AQA (A-LEVEL)
TOPIC:	ATOMIC STRUCTURE
PAPER TYPE:	SOLUTION -4
TOTAL QUESTIONS	8
TOTAL MARKS	58

Atomic Structure-4

Q.1

(a)

- Current model includes: Neutrons and protons whereas Rutherford doesn't.
- Current model shows electrons revolving around in different energy levels where as Rutherford model doesn't.

(b) Total number of elements are = 12 so electronic configurations will be

$$= 1s^2\ 2s^2 2p^6 3s^2$$

(c) The element has 12 Protons (Positive Charges) so the element is magnesium.
The formula would be 'Mgx_2' (General formula)

Q.2

(a) $cr = 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$
$cr^{2+} = 1s^2 2s^2 2p^6 3s^2 3p^6 3d^4$

(b) Third ionization of Fe equation
$Fe^{2+}{}_{(g)} \rightarrow Fe^{3+}{}_{(g)} + e^-$

Note: Don't forget is mention gasses state

(c) Electronic configuration of Aluminum and Sodium
Al = $1s^2 2s^2 2p^6 3s^2 3p^1$
Na = $1s^2 2s^2 2p^6 3s^1$
First electron to be removed from aluminum is from P- orbital whereas in sodium it is removed from s-orbital. It is easier it remove electron from P-orbital as compared to removing it from s-orbital.

(d) ^{20}Ne
Lightest ion would hit the detector first

(c) $R.A.M = \frac{\sum isotopic\ mass \times abundance}{Total\ abundance}$

$$= \frac{(20\times90.9)+(21\times0-3)+(22\times8-8)}{100}$$

$$= \frac{1818 + 6.3 + 193.6}{100}$$

$$= \frac{2017.9}{100} = 20.179\ amu.$$

Q.3

(a) R.AM $= \frac{\sum Isotopic\ mass\ \times abundance}{Total\ abundance}$

$$= \frac{(46 \times 9.1) + (47 \times 7.8) + (48 \times 76.6) + (49 \times 8.6)}{100}$$

$$= \frac{418.6 + 366.6 + 3580.8 + 421.4}{100}$$

$$= \frac{4787.4}{100} \quad = 47.874$$

(b) Equation for information of atom x.

$X_{(g)} \rightarrow X^{+1}{}_{(g)} + e^{-}$

(c) ^{49}x is the mass of one mole of atoms therefore one atom would weigh

$$= \frac{49}{6.02 \times 10^{23}} \quad = 8.14 \times 10^{-23} g$$

Now divide it by 1000 to convert into kg.

$$= \frac{8.14 \times 10^{-23}}{1000} = 8.14 \times 10^{-26}\ kg$$

(d) Important information

K.E $= 1.013 \times 10^{-13}$ J.

Time $= 9.816 \times 10^{-7}$ s.

Mass of one ion $^{49}x^{+} = 8.14 \times 10^{-26}$ kg.

Step 1: Formula mentioned in the question

$$t = d\sqrt{\frac{m}{2t}}$$

Could be questioned as

$$d = t\sqrt{\frac{2E}{m}}$$

Or if we take square so it becomes

$$d^2 = t^2 \times \frac{2E}{m}$$

Now,

$$d_1 = t_{49}\sqrt{\frac{2E}{m}} \quad \text{-----} \ (1) \text{ for } {}^{49}X^{+}$$

Similarly

$$d_2 = t_{47}\sqrt{\frac{2E}{m}} \quad \text{-----} \ (2) \text{ for } {}^{47}X^{+}$$

We know that distance is same for both so equating then $d_1 = d_2$

$$t_{47}\sqrt{\frac{2E}{47 \times 10^{-3}/_{NA}}} = t_{49}\sqrt{\frac{2E}{47 \times 10^{-3}/_{NA}}}$$

Note: In this equation we divide mass by Na (Avogadro's number)

$$t_{47}\sqrt{\frac{2E}{47\times10^{-3}/_{NA}}} = t_{49}\sqrt{\frac{2E}{47\times10^{-3}/_{NA}}}$$

Cancelling out on both sides

$$\frac{t_{47}}{\sqrt{47}} = \frac{t_{49}}{\sqrt{49}}$$

Time for $^{49}X^{+}$ is already given $= 9.816 \times 10^{-7} s.$

So

$$\frac{t_{47}}{\sqrt{47}} = \frac{9.816\times10^{-7}}{\sqrt{49}}$$

$$t_{47} = \frac{\sqrt{47} \times 9.816 \times 10^{-7}}{\sqrt{49}}$$

$$= 9.61 \times 10^{-7}$$

Q.4

(a) They have different number of neutrons.

(b) Isotopes have the same chemical properties as they have the same valence electrons due to same electronic configuration.

(c) Calculating the abundance of two isotopes

Step I:- Let's assume the abundance of ^{24}y be = x

The abundance of ^{25}y is $= 24.3$

Therefore, the abundance of ^{25}y is

$$= (100 - 24.3) - x$$

$$= 75.7 - x$$

Now

Isotope	abundance
^{24}y	x
^{25}y	24.3
^{26}y	$75.7 - x.$

Apply the formula;

$$R.A.M = \frac{\sum Isotopic\ mass \times abundance}{Total\ abundace}$$

$$24.3 = \frac{(24 \times x) + (25 \times 24.3) + 26(75.4 - x)}{100}$$

$$24.3 \times 100 = 24x + 607.5 + 1960.4 - 26x$$

$$2430 = 24x - 26x + 2567.0$$

$$2430 - 2567.9 = -2x$$

$$-137.9 = -2x$$

$$X = 68.95$$

The abundance are as follows:

$^{24}y = 68.95\%$

$^{25}y = 24.3\%$

$^{26}y = 6.75\%$

(d) Important information

$$K.E = 4.52 \times 10^{-16}$$
$$Time = 1.44 \times 10^{-5}$$
$$Ion = {}^{25}y^{+}$$

Step 1: mass of a single ion= $\frac{25}{6.02\times10^{23}}$

$= 4.1528 \times 10^{-23} g$

Step 2: convert the mass into kg by dividing it by 1000.

$= \frac{4.1528\times10^{-23}}{1000} = 4.15 \times 10^{-26} kg.$

Plug it into the equation

$$K.E = \frac{1}{2}mv^2$$

Note: The mass used in this equation is in kg.

$$4.52 \times 10^{-16} = \frac{1}{2}(4.15 \times 10^{-26})(v^2)$$

$$\sqrt{\frac{(4.52\times10^{-16})\times2}{4.15\times10^{-26}}} = v$$

$$v = 147591\ m/s$$

$$Step3: velocity = \frac{distance}{time}$$

$$distance = 2.12 metres$$

Q.5

(a)

Relative atomic mass of Z

$$R.A.M = \frac{(82\times5)+(83\times3)+(84\times26)+(86\times7)}{41(abundance)}$$
$$= \frac{410+249+2184+602}{41}$$
$$= \frac{3445}{41} = 84.02\ amu.$$

(b)

We know that $\frac{t_{82}}{\sqrt{82}} = \frac{t_{86}}{\sqrt{86}}$

(please read Q.3 past-(d) for the derivation of the formula)

Time for ${}^{82}Z^{+}$ $1.243 \times 10^{-5} s$

$$\frac{1.243\times10^{-5}}{\sqrt{82}} = \frac{t_{86}}{86}$$
$$t_{86} = \frac{(243\times10^{-5})\sqrt{86}}{\sqrt{82}}$$
$$t_{86} = 1.273 \times 10^{-5}$$

Q.6

(a) Potassium electronic configuration

$\Rightarrow 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$

(b) $k + H_2O \rightarrow KOH + H_2$

(C) Oxidizing agent

(d) $Na_{(g)} \rightarrow Na^+{}_{(g)} + e^-$

1. General Increase: As you move from left to right across Period 3, the ionization energy generally increases. This is due to an increase in the effective nuclear charge as more protons are added to the nucleus. The greater attraction between the positively charged nucleus and the negatively charged electrons requires more energy to remove an electron.

2. Zigzag Pattern: While there is a general increase, there is a zigzag pattern in the ionization energies. Elements on the left side of Period 3 (such as sodium and magnesium) have relatively low ionization energies, while elements on the right side (such as chlorine and argon) have significantly higher ionization energies. This is due to variations in electron configuration and subshell structure. Elements in the same group tend to have similar ionization energies.

3. Exceptions: There are a few notable exceptions to the general trend. For example, sulfur (S) has a lower ionization energy than phosphorus (P) because of the half-filled electron configuration in the p orbital of sulfur, which provides extra stability.

Q.7

(a) Abundance of third isotope of oxygen

$= 100 - (69.759 + 13.5)$

$= 16.741$

Isotopes	Abundance
16	79.759
17	13.5
X	16.741

We now can use the formula to calculate mass of third isotope as mass of oxygen given is 15.999

$$R.A.M = \frac{\sum Isotopic\ mass \times abundance}{Total\ abundance}$$

$$15.999 = \frac{(16\times69.759) + (17\times13.5) + (x\times16.741)}{100}$$

$$15.999 \times 100 = 1116.144 + 229.5 + 16.741x$$

$$1599.9 = 1345.644 + 16.741x$$

$$\frac{1599.9 - 1345.644}{16.741} = x$$

$x = 15.891.$

The mass of third isotope is = 15.891

(b) There are two methods of ionization
(1) electron impact method
(2) Electron spray ionization

(c)
(1) Only ions can be accelerated key an electron field.
(2) ions when fall on detected, general a current which is proportional to the abundance

Q.8

(a) $\{CH_3OCOCOOH\}^+$
$\{CH_3OCOCOOH_3\}^+$

(b) Positive ions are accelerated by on electric field.to a constant K.E Lighter ions well reach faster as compared to heavier.

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