ATOMIC STUCTURE TEST (beta)

42 MARKS

45 MINUTES

SCORE _____/ 42

tailoredtutors 2020

Q1.

Magnesium exists as three isotopes: ^{24}Mg, ^{25}Mg and ^{26}Mg

(a) In terms of sub-atomic particles, state the difference between the three isotopes of magnesium.

_____

_____

_____

(1)

(b) State how, if at all, the chemical properties of these isotopes differ.

Give a reason for your answer.

Chemical properties _____

_____

Reason _____

_____

_____

(2)

(c) ^{25}Mg atoms make up 10.0% by mass in a sample of magnesium.

Magnesium has A_r = 24.3

Use this information to deduce the percentages of the other two magnesium isotopes present in the sample.

^{24}Mg percentage = _____ % ^{26}Mg percentage = _____ %

(4)

(d) In a TOF mass spectrometer, ions are accelerated to the same kinetic energy (KE).

$KE = \frac{1}{2}mv^2$ where m = mass (kg) and v = velocity (m s^{-1})

$v = \frac{d}{t}$ where d = distance (m) and t = time (s)

In a TOF mass spectrometer, each $^{25}Mg^+$ ion is accelerated to a kinetic energy of 4.52×10^{-16} J and the time of flight is 1.44×10^{-5} s.
Calculate the distance travelled, in metres, in the TOF drift region.
(The Avogadro constant L = $6.022 + 10^{23}$ mol^{-1})

Distance = _____ m

(4)

(Total 11 marks)

Q2.

(a) A sample of sulfur consisting of three isotopes has a relative atomic mass of 32.16. The following table gives the relative abundance of two of these isotopes.

Mass number of isotope	32	33
Relative abundance / %	91.0	1.8

Use this information to determine the relative abundance and hence the mass number of the third isotope.
Give your answer to the appropriate number of significant figures.

Mass number = _____

(4)

(b) Describe how ions are formed in a time of flight (TOF) mass spectrometer.

_____

_____

_____

_____

_____

(2)

(c) A TOF mass spectrometer can be used to determine the relative molecular mass of molecular substances.

Explain why it is necessary to ionise molecules when measuring their mass in a TOF mass spectrometer.

_____

_____

_____

_____

_____

(2)

(Total 8 marks)

Q3.

The table below shows some successive ionisation energy data for atoms of three different elements **X**, **Y** and **Z**.

Elements **X**, **Y** and **Z** are Ca, Sc and V but not in that order.

	First	Second	Third	Fourth	Fifth	Sixth
X	648	1370	2870	4600	6280	12 400
Y	590	1150	4940	6480	8120	10 496
Z	632	1240	2390	7110	8870	10 720

(a) Which element is calcium?

X ⬭

Y ⬭

Z ⬭

(1)

(b) Which element is vanadium?

X ⬭

Y ⬭

Z ⬭

(1)

(c) Justify your choice of vanadium in part (b)

_____

_____

_____

(1)

(Total 3 marks)

Q4.

This question is about electron configuration.

(a) Give the full electron configuration of an Al atom and of a Cr^{3+} ion.

Al atom _____

Cr^{3+} ion _____

(2)

(b) Deduce the formula of the ion that has a charge of 2+ with the same electron configuration as krypton.

_____

(1)

(c) Deduce the formula of the compound that contains 2+ ions and 3− ions that both have the same electron configuration as argon.

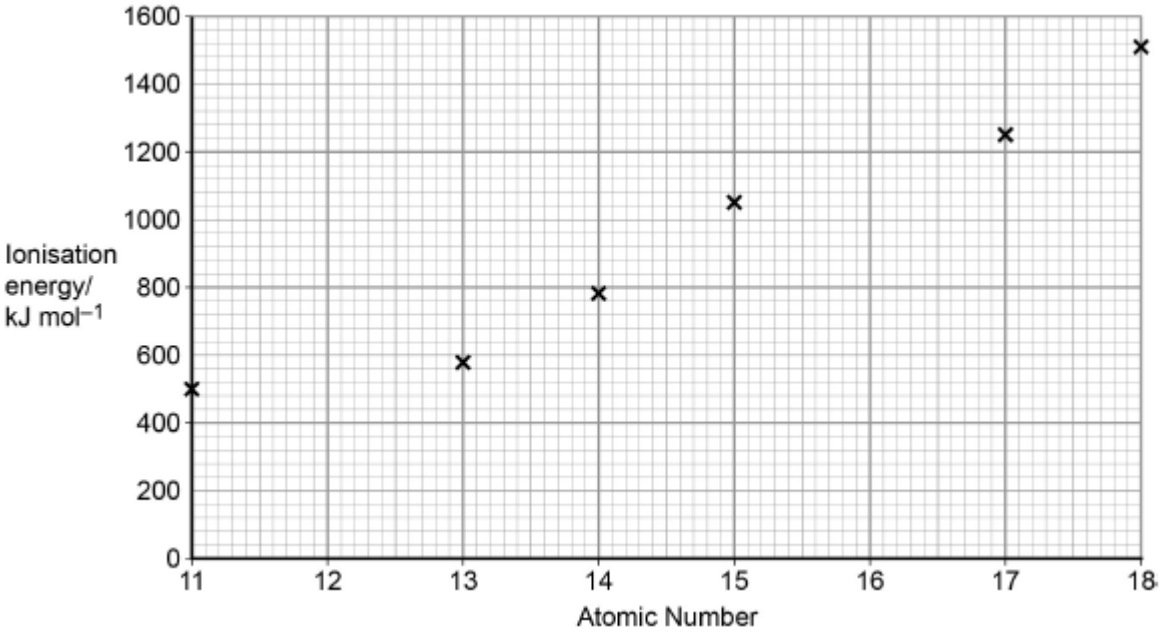
_____

(1)

(Total 4 marks)

Q5.

(a) The first ionisation energies of some Period 3 elements are shown in the following graph.



Complete the graph by plotting the approximate first ionisation energy values for magnesium and sulfur.

Explain why the first ionisation energy of sulfur is different from that of phosphorus.

(4)

(Total 4 marks)

Q6.

(a) Explain how ions are accelerated, detected and have their abundance determined in a time of flight (TOF) mass spectrometer.

(3)

(b) Calculate the mass, in kg, of a single $_{52}Cr^{+}$ ion.
Assume that the mass of a $_{52}Cr^{+}$ ion is the same as that of a $_{52}Cr$ atom.

(The Avogadro constant L = 6.022×10^{23} mol^{-1})

(1)

(c) In a TOF mass spectrometer the kinetic energy (KE) of a $_{52}Cr^{+}$ ion was 1.269×10^{-13} J

Calculate the velocity of the ion using the equation.

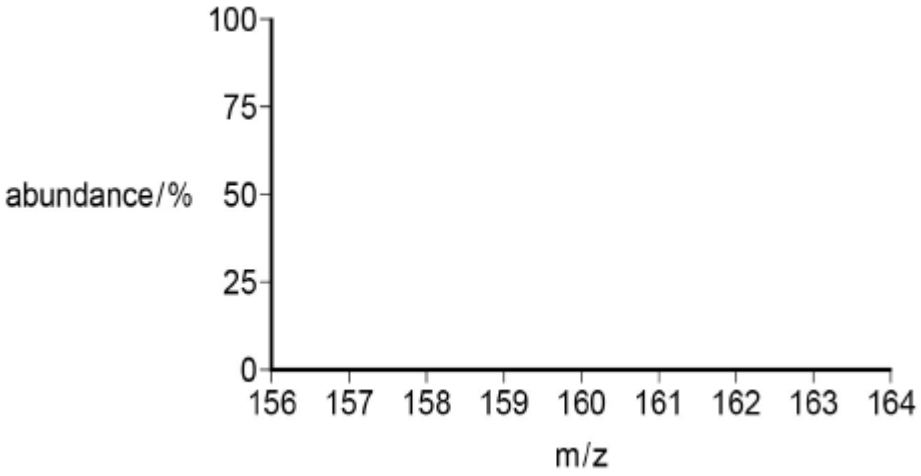
$$KE = \frac{1}{2}mv^2$$

(m = mass/kg and v = velocity/ms^{-1})

(2)

(d) Bromine has two isotopes, ^{79}Br and ^{81}Br, in approximately equal abundance. In a TOF mass spectrometer bromine forms ions with formula $[Br_2]^+$

Sketch the pattern of peaks you would expect to see in the mass spectrum of a sample of bromine.



(2)

(e) A sample of xenon has A_r = 131.31. The sample consists of four isotopes. The abundances of three of the isotopes are shown in the table below. The data for one of the isotopes, ^{m}Xe, is missing.

Isotope	^{129}**Xe**	^{131}**Xe**	^{132}**Xe**	^{m}**Xe**
% abundance	28.0	25.0	27.0	To be calculated

Use the data to calculate the abundance of isotope ^{m}Xe and calculate m, the mass number of ^{m}Xe. Show your working.

(4)

(Total 12 marks)