

SMART EXAM RESOURCES
9701 CAMBRIDGE AS CHEMISTRY
TOPIC QUESTIONS AND MARK SCHEMES
TOPIC :ATOMIC STRUCTURE
TOPIC:TREND IN IONISATION ENERGY

SET-2-QP-MS

1 Tellurium is an element in Group 16. The most common isotope of tellurium is ^{130}Te . Its electronic configuration is $[\text{Kr}] 4d^{10} 5s^2 5p$

(i) The radius of Te ions decreases after each successive ionisation.

State **two** factors that are responsible for the increase in the first six ionisation energies of Te.

.....

.....

..... [2]

(ii) Sketch a graph in Fig. 1.1 to show the trend in the first **seven** ionisation energies of Te.

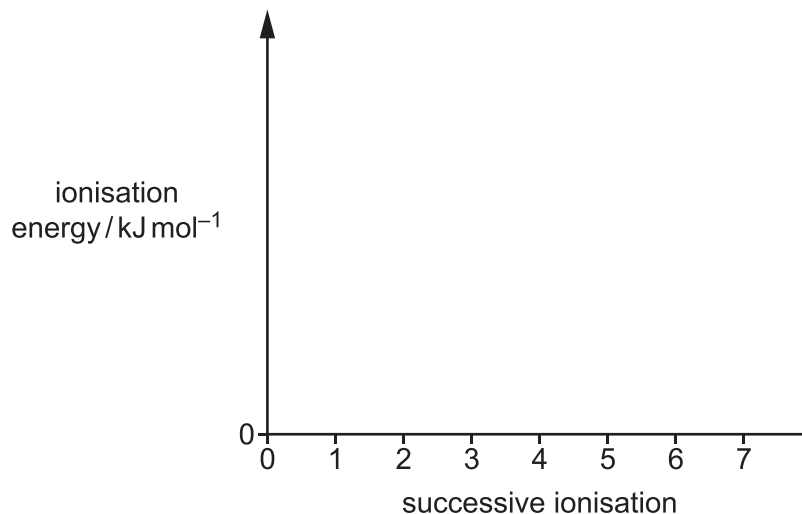
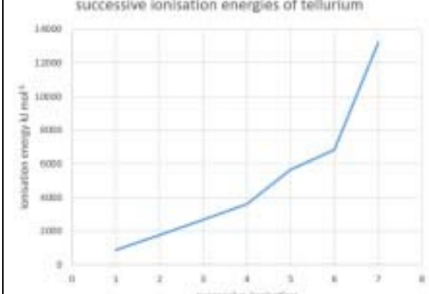


Fig. 1.1

[2]

MARK SCHEME:

(i)	<p>any two factors responsible for increase in IE in first 6 IE from:</p> <ul style="list-style-type: none"> • (increased) nuclear attraction / attraction for nucleus • (decreased) shielding (by sub-shells) (IE 4 to 5) • spin-pair repulsion (IE 1 to 2) 	2																		
(ii)	<p>successive ionisation energies of tellurium</p>  <table border="1" data-bbox="159 268 590 560"> <caption>Successive Ionisation Energies of Tellurium (Estimated from Graph)</caption> <thead> <tr> <th>Successive Ionisation</th> <th>Ionisation Energy / kJ mol⁻¹</th> </tr> </thead> <tbody> <tr><td>1</td><td>~1000</td></tr> <tr><td>2</td><td>~1500</td></tr> <tr><td>3</td><td>~2000</td></tr> <tr><td>4</td><td>~3500</td></tr> <tr><td>5</td><td>~5500</td></tr> <tr><td>6</td><td>~6500</td></tr> <tr><td>7</td><td>~13500</td></tr> <tr><td>8</td><td>~14000</td></tr> </tbody> </table> <p>M1 general increase M2 jumps from 4 to 5 and (largest) 6 to 7</p>	Successive Ionisation	Ionisation Energy / kJ mol ⁻¹	1	~1000	2	~1500	3	~2000	4	~3500	5	~5500	6	~6500	7	~13500	8	~14000	2
Successive Ionisation	Ionisation Energy / kJ mol ⁻¹																			
1	~1000																			
2	~1500																			
3	~2000																			
4	~3500																			
5	~5500																			
6	~6500																			
7	~13500																			
8	~14000																			

2 In the Periodic Table, the p block contains elements whose outer electrons are found in the p subshell.

Explain why there is a general increase in first ionisation energies of the elements across Period 3.

.....

.....

.....

..... [2]

MARK SCHEME:

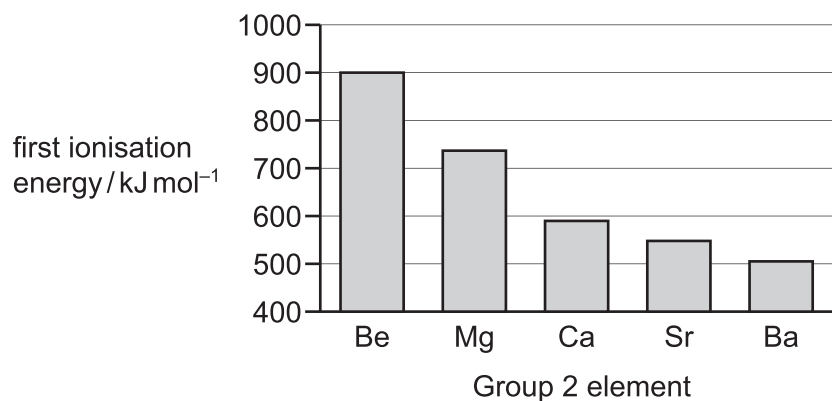
4

M1: similar shielding AND increase in proton number / atomic number / nuclear charge

2

M2: increased nuclear attraction

3 The graph shows the first ionisation energies of some of the elements in Group 2.



(a) Explain the observed trend in first ionisation energies down Group 2.

.....
.....
.....
.....
.....
..... [3]

(b) The second ionisation energy of Be is 1757 kJ mol⁻¹.

Explain why the second ionisation energy of Be is higher than the first ionisation energy of Be.

.....
.....
.....
..... [2]

MARK SCHEME:

(a)	M1: distance between nucleus and outer e⁻ increases OR outer electron removed from higher energy shell	3
	M2: increased shielding	
	M3: decreased nuclear attraction	
(b)	M1: greater nuclear attraction	2
	M2: (2nd / 2s) electron being removed from smaller (ion)	

4

The elements phosphorus, sulfur and chlorine are in Period 3 of the Periodic Table.

Table 1.1 shows some properties of the elements P to Cl.

The first ionisation energy of S is **not** shown.

Table 1.1

property	P	S	Cl
number of electrons in 3p subshell			
total number of unpaired electrons			
first ionisation energy /kJ mol ⁻¹	1060		1260
formula of most common anion	P ³⁻	S ²⁻	Cl ⁻

(a)

[2]

Three possible values for the first ionisation energy of S are given.

1000 kJ mol⁻¹

1160 kJ mol⁻¹

1320 kJ mol⁻¹

Circle the correct value.

Explain your choice by comparing your chosen value to those of P and Cl.

.....

.....

.....

.....

.....

.....

..... [4]

MARK SCHEME:

1000 (kJmol ⁻¹)	1
(S) less / least / lowest nuclear attraction (to outer electrons) (than P OR Cl) OR nuclear attraction for Cl is stronger (compared to S (and or P))	1
S less nuclear charge than Cl OR Cl has a greater nuclear charge than S	1
(S has a greater nuclear charge (of outer electrons) than P BUT) S has two electrons in a (3)p orbital AND resulting in spin-pair repulsion	1

5

Table 1.1 shows some properties of the elements Si to S.

The first ionisation energy of P is **not** shown.

Table 1.1

property	Si	P	S
total number of electrons in s subshells			
total number of electrons in p subshells			
first ionisation energy/ kJ mol^{-1}	786		1000
formula of most common chloride	SiCl_4	PCl_5	SCl_2

Three possible values for the first ionisation energy of P are given.

619 kJ mol^{-1}

893 kJ mol^{-1}

1060 kJ mol^{-1}

Circle the correct value.

Explain your choice, including a comparison of your chosen value to those of Si and S.

.....

.....

.....

.....

.....

.....

..... [4]

MARK SCHEME:

1060 (is circled)	1
P / it has greater attraction of nucleus for outer electrons compared to Si ORA	1
P / it has greater nuclear charge than Si ORA	1
S has two electrons in a (3)p orbital AND resulting in spin-pair repulsion	1