ACADEMIC ASSOCIATES
Make Success a Reality

CHEMISTRY

UNIT 1 Semester One 2019

Marking Key

Marking keys outline the expectations of examination responses. They help to ensure a consistent interpretation of the criteria that guide the awarding of marks.

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of examination
Section One Multiple-choice	25	25	50	50	25
Section Two Short answer	9	9	60	85	35
Section Three Extended answer	6	6	70	87	40
				Total	100

Section One: Multiple–choice **25% (50 Marks)**

Question No.	Answer
1	A
2	C
3	B
4	D
5	B
6	C
7	A
8	D
9	A
10	D
11	D
12	A
13	B
14	B
15	C
16	B
17	C
18	D
19	A
20	C
21	D
22	A
23	C
24	A
25	B

A=7	B=6	C=6	D=6

Section Two: Short answer **35% (85 Marks)**

Question 26 **(6 marks)**

Complete the table below.

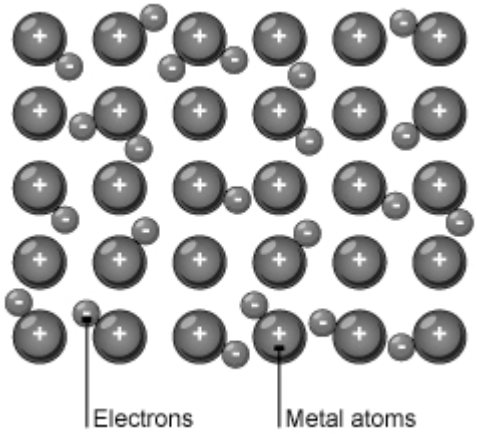
Description		Marks
See table below.		
Formula	**Name**	
Na_2CrO_4	Sodium Chromate	1
N_2O_4	Dinitrogen tetroxide	1
$Fe(H_2PO_4)_3$	Iron (III) dihydrogenphosphate	1
$NaMnO_4$	Sodium permanganate	1
$(NH_4)_2SO_4$	Ammonium sulfate	1
CBr_4	Tetrabromomethane	1
	Total	**6**

Formula	Name
Na_2CrO_4	Sodium Chromate
N_2O_4	Dinitrogen tetroxide
$Fe(H_2PO_4)_3$	Iron (III) dihydrogenphosphate
$NaMnO_4$	*Sodium permanganate*
$(NH_4)_2SO_4$	*Ammonium sulfate*
CBr_4	*Tetrabromomethane*

Question 27 **(10 marks)**

Group 1 elements are also known as alkali metals and Group 2 elements are known as alkaline earth metals.

(a) Describe with the, **aid of a diagram**, the bonding present in sodium metal. (3 marks)

Description	Marks
Diagram:  	1
Sodium consists of positive ions embedded in a 'sea' of electrons	1
The forces of attraction that exist between the positive and the negative ions are known as electrostatic force of attraction.	1
Total	**3**

(b) Metals are noted for their thermal conductivity and generally high melting point. Explain these physical properties of metals by referring to the metallic bonding model. (4 marks)

Description	Marks
Thermal	
the close packing of the **metal** ions in the lattice.	1
the delocalised electrons can carry kinetic energy through the lattice.	1
Melting Point	
High attraction between protons and the sea of electrons	1
The attraction must be overcome to melt or to boil a metal. These attractive forces are strong, so metals have high melting and boiling points	1
Total	**4**

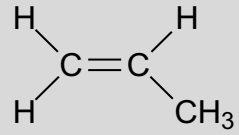
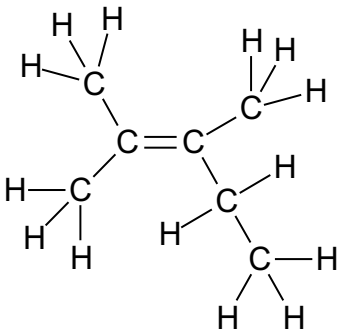
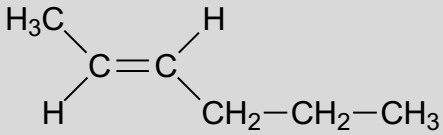
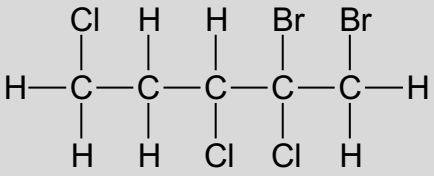
When sodium metal reacts with chlorine gas, it produces a white solid.

(c) The white solid does not conduct electricity. However, if it is heated until it melts, the liquid will conduct electricity. Explain this behaviour. (3 marks)

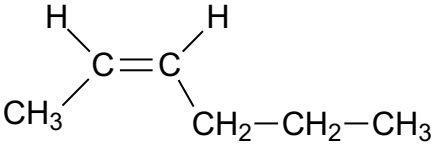
Description	Marks
The ionic lattice has no free charge carriers	1
When molten the positive ions will accept electrons and the negative ions will lose them	1
The molten substance will conduct electricity	1
Total	**3**

Question 28 **(16 marks)**

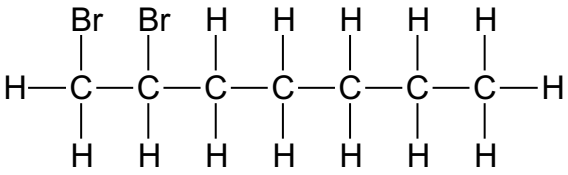
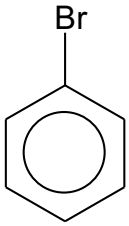
(a) Complete the table below. (8 marks)

Description		Marks
Structural Formula	**IUPAC Name**	
	propene	2
	2,3–dimethylpent–2–ene	2
	*trans*–hex-2-ene	2
	1,2–dibromo–2,3,5–tricloropentane	2
	Total	**8**

(b) Select one molecule from the table in part (a) that can exist as a *cis* isomer and draw its *cis* structure below. (2 marks)

Description	Marks
	2
Total	**2**

(c) Samples of benzene and hept–1–ene appear similar in that they are colourless, clear liquids. Their chemical reactions, however are quite different. Draw the full structural formula of the organic product when bromine water reacts with each of these substances and name the product. (6 marks)

Description	Marks
	2
1,2–dibromoheptane	1
	2
bromobenzene	1
Total	**6**

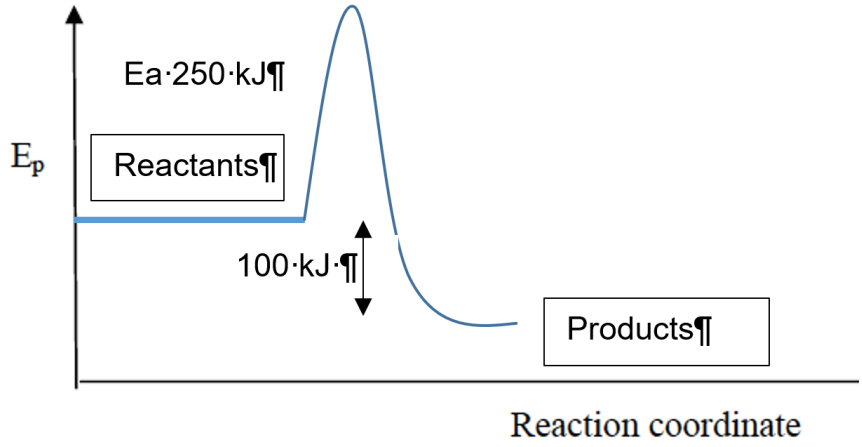
Question 29 **(9 Marks)**

The combustion of hydrogen gas can be represented as follows:

$$2\ H_2(g)\ +\ O_2(g)\ \rightarrow\ 2\ H_2O(g)\ +\ \text{heat}$$

(i) The activation energy of the reaction is 250 kJ mol^{-1}.
(ii) The enthalpy change for the reaction is 100 kJ mol^{-1}.
(iii) Finely divided iron filings are used in the reaction as a catalyst.

(a) On the axes below sketch an appropriate and clearly labelled energy profile diagram for the above reaction. Include the reactants, products, activation energy and the enthalpy change. (5 marks)

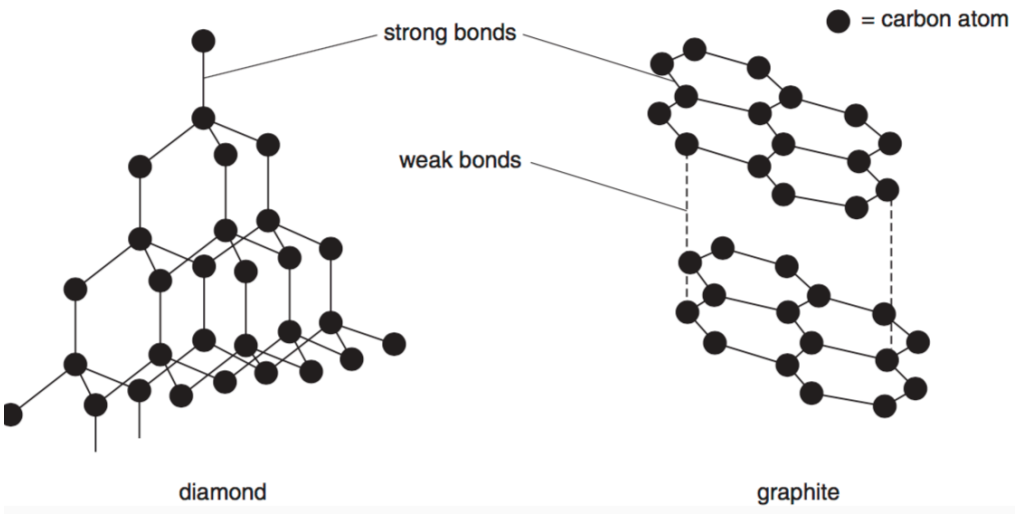
Description	Marks
	
Products and reactants must be mentioned as per equation.	2
Correct values for activation and enthalpy change must be used.	2
Correct shape.	1
Total	**5**

(b) State and explain the effect the finely divided iron filings have on the reaction. (4 marks)

Description	Marks
The iron filings provide an alternative pathway	1
of lower activation energy	1
Therefore, more particles can overcome the energy barrier	1
The rate of reaction increases	1
Total	**4**

Question 30 **(11 Marks)**

The structures of diamond and graphite are drawn below.



(a) State the name of the "strong bonds" shown on the diagram in the space below. (1 mark)

Description	Marks
Covalent bonds	1
Total	**1**

(b) Diamond is noted for its hardness and graphite is used as a lubricant because of its soft slippery properties.

(i) Explain why there is such a difference in this physical property of these carbon structures. (3 marks)

Description	Marks
In diamond there are only strong covalent bonds (tetrahedral structure)	1
Whereas in graphite there is a layer structure with weak intermolecular forces of attraction	1
Therefore, less energy will be involved in overcoming the weak forces of attraction resulting in graphite being softer than diamond.	1
Total	**3**

(ii) Explain why there is a significant difference in the electrical conductivity of diamond and graphite. (2 marks)

Description	Marks
Graphite conducts electricity, diamond does not.	
Graphite has delocalised electrons between the layers that act as charge carriers.	1
All the electrons in diamond have been used in bonding.	1
Total	**2**

Question 30 (continued)

(c) Carbon is also found in nanomaterials. Describe how the structure of a carbon nano-particle is different in three ways from either structure in part (a). (3 marks)

Description	Marks
Size: Nano-particles are very small	1
Shape: tend to be made into a ball or tube shape	1
Structure: bonded in rings of either 5 or 6 carbons	1
Total	**3**
Accept any other relevant answers.	

(d) List **two** possible health issues that might be related to the use of nano-particles. (2 marks)

Description	Marks
One mark each to a maximum of two marks.	
Any **two** of: • Properties of nano-particles differ (from the 'bulk' corresponding chemical) and the hazards are largely unknown • They are small enough to penetrate the lung cells • They are much smaller than body cells and so could enter body cells	1-2
Total	**2**
Accept any other relevant answers.	

Question 31 **(13 marks)**

The table below shows some of the ores of iron that are mined in Western Australia.

Ore	Formula
Haematite	Fe_2O_3
Magnetite	$FeO.Fe_2O_3$
Siderite	$FeCO_3$

(a) By calculation, determine and state which ore has the greatest percentage by mass of iron. (4 marks)

Description	Marks
Haematite = 111.7 / 159.7 x 100 = 69.94 %	1
Magnetite = 167.55 / 231.55 x 100 = 72.36 %	1
Siderite = 55.85 / 115.86 x 100 = 48.20 %	1
Magnetite has the highest % by mass of iron	1
Total	**4**

(b) Iron is malleable. Define malleability and explain this property by referring to its structure and bonding. (4 marks)

Description	Marks
Iron is malleable which means it can be hammered into different shapes	1
the forces of attraction between the particles are non-directional	1
Whenever an external force is applied the atoms slide over each	1
other as the forces of attraction are non-directional which allows movement to occur	1
Total	**4**

Question 31 (continued)

(c) Certain physical properties of iron can be changed by the addition of carbon when the iron is molten. This new substance is called an alloy. Construct a suitable diagram and explain why a property of iron changes when it becomes an alloy. (3 marks)

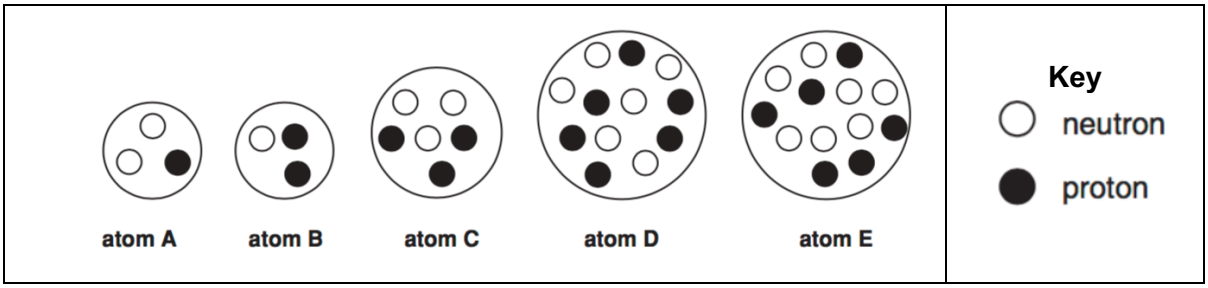
Description	Marks
Diagram showing atoms of two different radii.	1
Alloys are less malleable	1
because of the different sized atoms which disrupt the orderly manner in which they are arranged and therefore prevent sliding over each other easily.	1
Total	**3**

(d) Explain why alloys are described as homogeneous mixtures. (2 marks)

Description	Marks
they have uniform composition	1
and properties throughout the substance	1
Total	**2**

Question 32 **(13 marks)**

The diagram below shows the nuclei of five different atoms.



(a) Which atom has an atomic number of 3? (1 mark)

Description	Marks
Atom C	1
Total	**1**

(b) Which atom has a mass number of 12? (1 mark)

Description	Marks
Atom D	1
Total	**1**

(c) A mass spectrometer can be used to determine the proportion of each isotope present in a sample of an element.

(i) Define the term “isotope”. (2 marks)

Description	Marks
Isotopes are atoms of the same element having same number of protons	1
but different number of neutrons	1
Total	**2**

(ii) Name the **four** steps used in mass spectrometry to detect an isotope. (4 marks)

Description	Marks
One: ionisation	1
Two: acceleration	1
Three: deflection	1
Four: detection	1
Total	**4**

Question 32 (continued)

(iii) Lithium has two naturally occurring isotopes: (2 marks)

Li – 6: natural abundance 7%

Li – 7: natural abundance 93%

Calculate the relative atomic mass of lithium.

Description	Marks
RAM = (7 /100 x 6) + (93 /100 x 7)	1
= 0.42 + 6.51 = 6.93	1
Total	**2**

(d) Sodium atoms and potassium atoms have different radii. Compare their atomic radius and explain the difference in size. (3 marks)

Description	Marks
Sodium atom has a smaller radius compared to potassium atom	1
Effective nuclear charge is lower for sodium compared to potassium / screening effect is more for potassium.	1
This implies that the valence electrons are pulled more closer in case of sodium.	1
Total	**3**

Question 33 **(3 marks)**

"Carbon dioxide is a molecular compound and it is a non–conductor of electricity".
Explain the above statement.

Description	Marks
Carbon is covalently bonded to oxygen atoms as they are non-metals and exist as discrete molecules	1
There are no electrons present as they are all shared in covalent bonds	1
No conduction of electricity	1
Total	**3**

Question 34 **(4 marks)**

Using an appropriate example from your practical work this year, explain the difference between the independent variable and the dependent variable in an investigation.

Description	Marks
Valid Experiment Chosen	1
Aim stated	1
Independent Variable: identified	1
Dependent Variable: identified	1
Total	**4**

End of Section Two

Section Three: Extended answer **40% (87 Marks)**

Question 35 **(18 marks)**

The table below lists the boiling points of some alkanes and their state at room temperature (25 °C).

Name	Formula	Boiling point (°C)	State
Ethane	C_2H_6	–89	*Gas*
Propane	C_3H_8	–42	Gas
Methyl propane	*$CH_3CH(CH_3)CH_3$*	–11.7	Gas
Butane	*C_4H_{10}*	–1	Gas
Pentane	C_5H_{12}	36	Liquid
Hexane	C_6H_{14}	69	*Liquid*

(a) Complete the table above. (4 marks)

Description	Marks
Ethane State= Gas	1
Methyl propane Formula = *$CH_3CH(CH_3)CH_3$*	1
Butane Formula = *C_4H_{10}*	1
Hexane State = Liquid	1
Total	**4**

(b) State and explain the trend in boiling points of butane, pentane and hexane, by referring to the intermolecular forces present. (5 marks)

Description	Marks
Butane, Pentane and Hexane are non-polar substances	1
Dispersion forces are present and they are weak	1
Dispersion forces depend on the number of electrons used in bonding / molar mass/surface area	1
Hexane has a larger molar mass and therefore will have a higher boiling point compared to the others	1
The total energy required to disrupt the sum of the bonds is reflected in the boiling points	1
Total	**5**

(c) Butene is an unsaturated hydrocarbon. How does an unsaturated hydrocarbon differ structurally from a saturated hydrocarbon? (2 marks)

Description	Marks
A substance consisting of carbon and hydrogen atoms only	1
There is presence of double bonds in between one or more carbon atoms in unsaturated hydrocarbons while saturated have only single bonds.	1
Total	**2**

(d) Describe a chemical test to distinguish between oct–1–ene and octane. Include any conditions, balanced chemical equations and observations for any reactions taking place. (7 marks)

Description	Marks
Aqueous bromine is added to the substances separately in 2 test tubes	1
Orange colour fades	1
The test tube in which the bromine its decolourised faster contains octene	1
$CH_2CHC_6H_{13} + Br_2 \rightarrow CH_2BrCHBrC_6H_{13}$	2
$C_8H_{18} + Br_2 \rightarrow C_8H_{17}Br + HBr$	2
Total	**7**

Question 36 **(14 marks)**

Design a process where, if you were given a mixture of iron filings, salt and charcoal, you could separate each component.

(a) Prepare a list of essential equipment you will need to request to complete this exercise. (5 marks)

Description	Marks
Safety items	
Any **three** of: • Glasses • Aprons • bench mat • gloves	1-3
Adequate equipment list	1-2
Total	**5**

(b) Describe how you would separate the different substances from the mixture. Identify the separation techniques you would choose and show two details of how each one specifically separates an item from the mixture. (9 marks)

Description	Marks
Separation technique - Magnet	
Magnet	1
Iron filings can be separated by the use of a magnet	1
Water is added to the remaining mixture	1
Separation technique - Filtration	
Filtration	1
Any **two** of: • Salt dissolves and charcoal does not • The charcoal is separated by filtration • Charcoal is the residue • Saltwater is the filtrate • Particle size	1-2
Separation technique - Crystallisation	
Crystallisation	1
Any **two** of: • Salt water now is heated • Allow to cool • Salt crystallises out	1-2
Total	**9**

Question 37 **(12 marks)**

Sophie carried out experiments on some substances to learn more about them. The table below summarises her results.

Substance	Conducts electricity	Melting point
X	In the solid state and liquid states	High
Y	In the liquid state only	High
Z	In the solid state	Very high

(a) Using the results in the table above, classify substances X, Y and Z as either covalent network (CN), metallic (M), or ionic (I). Explain your reasoning. (12 marks)

Description	Marks
X	
X is a metal	1
Conduction is due to delocalised electrons	1
It has a high melting point because of the strong electrostatic forces of attraction between positive and the negative electrons	1
Much of energy is required to overcome the forces of attraction	1
Y	
Y is an ionic solid	1
It conducts electricity only in the molten state because the ions are free to move	1
It has a high melting point because of the strong electrostatic forces of attraction between the ions	1
Much energy is required to overcome the forces of attraction	1
Z	
Z has a covalent structure and it is graphite	1
It has delocalised electrons responsible for the conduction of electricity as not every electron is used in bonding	1
It has very high melting point because of the presence of large amount of covalent bonds	1
Energy required to break them is high	1
Total	**12**

Question 38 **(8 marks)**

Calcium carbonate is used in some toothpastes. To determine the mass of calcium carbonate in one gram of toothpaste, a 10.40 g sample of the toothpaste was reacted with hydrochloric acid solution.

When calcium carbonate reacts with hydrochloric acid solution the products are calcium chloride, water and carbon dioxide.

(a) If the molecular equation describing this reaction is

$$CaCO_3 + 2HC\ell \rightarrow CaC\ell_2 + CO_2 + H_2O$$

Write a balanced ionic equation for the reaction taking place, include state symbols. (2 marks)

Description	Marks
$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(\ell)$	1
State symbols	1
Total	**2**

(b) If 3.570 g of carbon dioxide is produced, calculate the mass of calcium carbonate present in the 10.40 g sample. (4 marks)

Description	Marks
$n(CO_2) = 3.570 / 44.01$ (1) = 0.08111 mol	1
$n(CaCO_3) = n(CO_2) = 0.08111$ mol	1
$m(CaCO_3) = nM = 0.0811 \times 100.09 = 8.119$ g	1
correct units	1
Total	**4**

(c) Calculate the mass of calcium carbonate in one gram the toothpaste. (1 mark)

Description	Marks
8.12 / 10.40 = 0.781 g	1
Total	**1**

(d) By referring to the given equation in part (a) state what assumption has been made about the reaction of the acid with the toothpaste. (1 mark)

Description	Marks
That the reaction went to completion i.e. the toothpaste was the limiting reagent and there was equal or more than 2 mol of $HC\ell$ per mol of calcium carbonate.	1
Total	**1**
Accept any valid assumption.	

Question 39 **(21 marks)**

The following table shows the first ionisation energy for some elements in Group I.

Group 1	First Ionisation energy in kJ mol^{-1}
Lithium	526
Sodium	504
Potassium	
Rubidium	410

(a) Write an equation to demonstrate the second ionisation energy of sodium. (1 mark)

Description	Marks
$Na^{+}(g) \rightarrow Na^{2+}(g) + e^{-}$	1
Total	**1**

(b) Complete the table by estimating the ionisation energy of potassium. (1 mark)

Description	Marks
450 ± 30	1
Total	**1**

(c) State and explain the trend in ionisation energy shown in the table. (4 marks)

Description	Marks
First ionisation energy decreases down the group	1
Atomic radius gets bigger	1
Effective nuclear charge gets smaller	1
Easier to remove most loosely held electrons	1
Total	**4**

(d) Why is the second ionisation energy of an atom larger than the first ionisation energy? (3 marks)

Description	Marks
More protons / electron	1
Removing a negative electron form a positive ion	1
Total	**3**

Question 39 (continued)

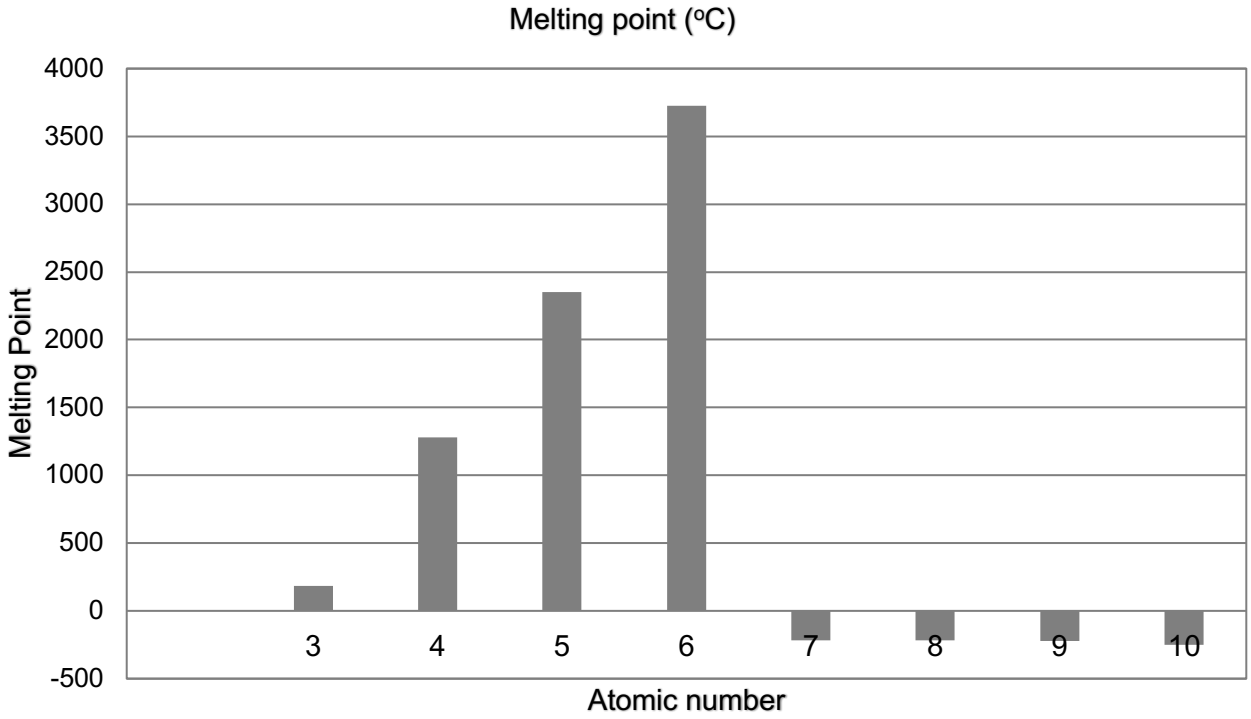
Below is a table showing the atomic radius and melting point for the second Period elements.

Element	Atomic Radius (pm) (1 picometre = 10^{-12}m)	Melting point (°C)
Lithium	145	182
Beryllium	105	1280
Boron	85	2350
Carbon	70	3727
Nitrogen	65	–215
Oxygen	60	–219
Fluorine	50	–222
Neon	38	–251

(e) (i) State and explain the trend in atomic radius across the second Period. (3 marks)

Description	Marks
Increasing atomic number	1
Increasing positive charge	1
More attraction for electrons – smaller radius	1
Total	**3**

(ii) Plot a suitable graph of atomic number against melting point for the second Period elements. (6 marks)



Description	Marks
These data are discrete. There is no atomic number e.g. 4.5 so ideally, should have a bar graph or similar	1
Title	1
Appropriate scale on vertical axis	1
Atomic no on x axis	1
Labelled axes	1
Correct plotting	1
Total	**6**

(iii) State and explain the difference in melting points of lithium, nitrogen and neon.
(3 marks)

Description	Marks
There is a decrease in melting point	1
There is a change from metallic character to non-metallic character	1
Forces of attraction is stronger in nitrogen compared to neon	1
Total	**3**

Question 40 **(14 Marks)**

Commercial production of nitric acid is by the Ostwald process, named after German chemist Wilhelm Ostwald. In this process, anhydrous ammonia reacts with oxygen gas to form nitric oxide (NO) and water, in the presence of a platinum catalyst at a high temperature of about 500 K and a pressure of 9 atm.

(a) Write a balanced chemical equation for the reaction above, include state symbols. (4 marks)

Description	Marks
$4\ NH_3(g) + 5\ O_2(g) \xrightarrow{Pt} 4\ NO(g) + 6\ H_2O(g)$	
Correct species	1
Balanced	1
Correct states – note at 500 K water is a gas	1
Catalyst shown	1
Total	**4**

Subsequently the NO is reacted with more oxygen and water

Equation Two : $4\ NO(g) + 3\ O_2(g) + 2\ H_2O(\ell) \rightarrow 4\ HNO_3(aq)$

Overall, starting with ammonia, the Ostwald Process can be represented as

Equation Three : $NH_3(g) + 2\ O_2(g) \rightarrow HNO_3(aq) + H_2O(\ell)$

(b) A reactor contains 2.180 kg of ammonia gas. If the ammonia is fully consumed in the reaction, **using Equation Three**, calculate:

(i) the number of moles of ammonia that reacted. (3 marks)

Description	Marks
$M(NH_3) = 2.180 \times 10^3$ g	1
$n(NH_3) = m/M = 2.180 \times 10^3 / 17.034$	1
= 128.0 mol	1
Total	**3**

(ii) the number of particles of ammonia that reacted. (2 marks)

Description	Marks
$n(NH_3) = 6.022 \times 10^{23} \times n$ $= 6.022 \times 10^{23} \times 127.979$ $= 7.71 \times 10^{25}$ molecules	1-2
Total	**2**

Question 40 (continued)

(iii) The mass of oxygen gas consumed. (2 marks)

Description	Marks
$n(NH_3) = 128.0$ mol $\therefore n(O_2) = 256.0$ mol	1
$m(O_2) = 32 \times 256.0 = 8190$ g $= 8.19 \times 10^3$ g	1
Total	**2**

(iv) The mass of nitric acid produced. (3 marks)

Description	Marks
$n(NH_3) = 128.0$ mol	
$n(HNO_3) = 128.0$ mol	1
$m = n \times M = 128 \times 63.01$	1
$= 8\ 065$ g $= 8.065 \times 10^3$ g	1
Total	**3**