Cambridge Assessment International Examination

Chemistry

O Level Topical Paper 2

700+ Theory Question with Mark Scheme

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Compiled By:

NIAZ AHMED AWAN

niaz.awan564@gmail.com +923004255956

Senior A Level Chemistry at Lahore Grammar School

Visiting Faculty Member at:

Beaconhouse (Newlands & JT Campuses)

LGS, KIMS, The City School, SICAS, LACAS

Endorsed By:

UMAR ZAMAN KHATTAK

HOD: Garrison Academy for Cambridge Studies

HAMID MAHMOOD

Beaconhouse Palm Tree Campus Gujranwala.+92322-7126666

NOUMAN AHMAD

A Level Chemistry Teacher at: Aitchison College, Lahore

MUHAMMAD SAQIB

Chemistry Teacher at: Lahore Grammar School JTC

MUHAMAD ASHFAQ

O & A Level Chemistry Teacher at: LACAS, LGS, Lahore Lyceum

SHAHBAZ YASEEN

O & A Level Chemistry Teacher at: LACAS, Johar Town

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CONTENT
O LEVEL CHEMISTRY TOPICAL P2

I am a teacher. It's how I define myself.

A good teacher isn't someone who gives the answers out to their Students but is understanding of needs and challenges and gives tools to help other people succeed.
That's the way I see myself, so whatever it is that I will do, it'll have to do a lot with teaching.

NIAZ AHMED AWAN
CIE Chemistry / +923004255956
"ÅÁÃÏ ÎÈÏÕÓÅ 3ÃÈÏ ÏÌ 3ÙÓÔÅ Í (ALJT, and Newlands Campus)
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1. States of Matter

1 5070/22/M/J/23/Q2(c)

(c) The rate of diffusion of fluorine gas is greater than that of chlorine gas under the same conditions of temperature and pressure.

(i) State what is meant by the term diffusion.

.....

..... [1]

(ii) Explain why the rate of diffusion of fluorine is greater than that of chlorine under the same conditions.

.....

..... [1]

(iii) The rate of diffusion of fluorine increases as the temperature increases.

Suggest why using ideas about kinetic particle theory.

.....

..... [1]

---

2 5070/21/M/J/21/Q2(f)

(f) A sample of neon has a volume of 21 dm^3 at room temperature and pressure.

(i) The temperature of the sample is increased. The pressure remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

..... [1]

(ii) The pressure of the sample is increased. The temperature remains constant.

Describe and explain, using kinetic particle theory, what happens to the volume of the sample.

.....

..... [1]

---

3 5070/22/O/N/20/Q3(a)

(a) A drop of black ink is placed at the bottom of a beaker of water.

After a time, the colour of the ink spreads throughout the water.

Explain this observation in terms of the kinetic particle theory.

.....

..... [3]

4 5070/21/O/N/20/Q4(a)

This question is about halogens and halogen compounds.

(a) A drop of bromine liquid was placed in a sealed glass jar.

After a time, the colour of the bromine had spread throughout the jar.

Explain this observation in terms of the kinetic particle theory.

.....

..... [3]

---

5 5070/21/M/J/20/Q7(d)

(d) When warmed, solid carbon dioxide changes directly into a gas. It does **not** become a liquid. Use the kinetic particle theory to describe the changes in **movement** and **arrangement** of the particles during this change of state.

.....

..... [3]

---

6 5070/22/M/J/16/Q3/b 5070/21/M/J/16/Q3/c

Ethyl ethanoate evaporates at room temperature.

(i) What is meant by the term *evaporation*?

..... [1]

(ii) A sample of ethyl ethanoate in a beaker is moved into a colder room.

Explain, in terms of the kinetic particle theory, why this results in a decrease in the rate of evaporation.

..... [2]

(iii) The table shows some information about different esters.

name	structure	relative molecular mass (M_r)
methyl methanoate	HCO_2CH_3	60
ethyl methanoate	$HCO_2C_2H_5$	74
propyl methanoate	$HCO_2C_3H_7$	88
butyl methanoate	$HCO_2C_4H_9$	102
pentyl methanoate	$HCO_2C_5H_{11}$	116

Which ester has the **greatest** rate of diffusion at room temperature and pressure?

.....

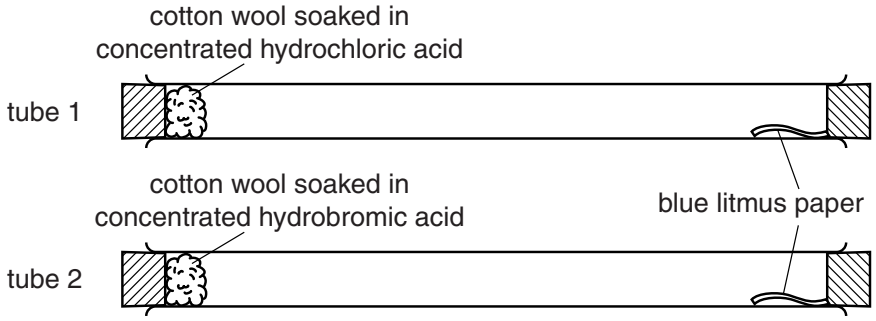
Explain your answer.

.....

[2]

7 5070/22/O/N/15/Q5

(a) Two students set up tubes as shown.



Concentrated hydrochloric acid produces fumes of hydrogen chloride.
Concentrated hydrobromic acid produces fumes of hydrogen bromide.

Four minutes after setting up the experiment, the litmus paper in tube 1 turns red.
Seven minutes after setting up the experiment, the litmus paper in tube 2 turns red.

Use the kinetic particle theory to explain

(i) how the gases move through the tubes,

.....

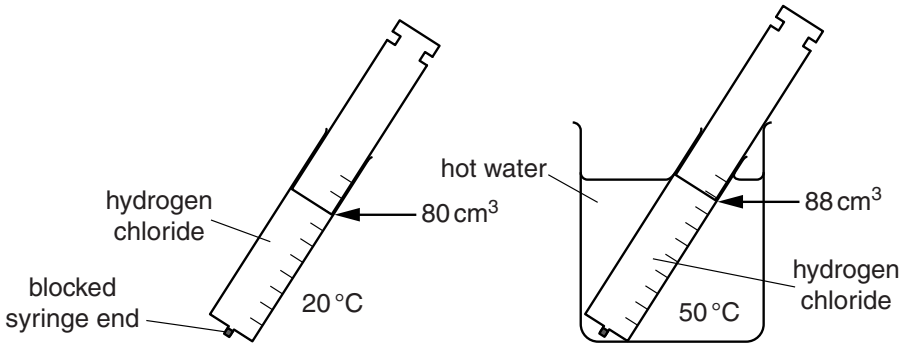
.....[2]

(ii) why the gases take different times to reach the litmus paper.

.....

.....[1]

(b) A gas syringe is filled with 80 cm^3 of hydrogen chloride gas at 20 °C.
The syringe is placed in some hot water at 50 °C.
The atmospheric pressure does not change but the volume of the gas in the syringe increases to 88 cm^3.



Use the kinetic particle theory to explain why the volume increases.

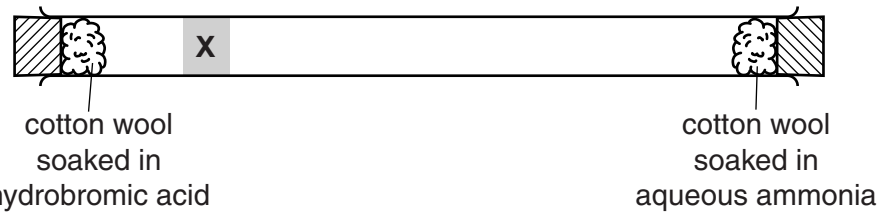
.....

.....

.....[2]

8 5070/21/O/N/15/Q5

A student set up a tube as shown in the diagram.



Concentrated hydrobromic acid produces fumes of hydrogen bromide.
Concentrated aqueous ammonia produces fumes of ammonia.

(a) After some time, solid ammonium bromide appeared on the walls of the tube at point **X**.

Use the kinetic particle theory to explain this result.

.....

.....

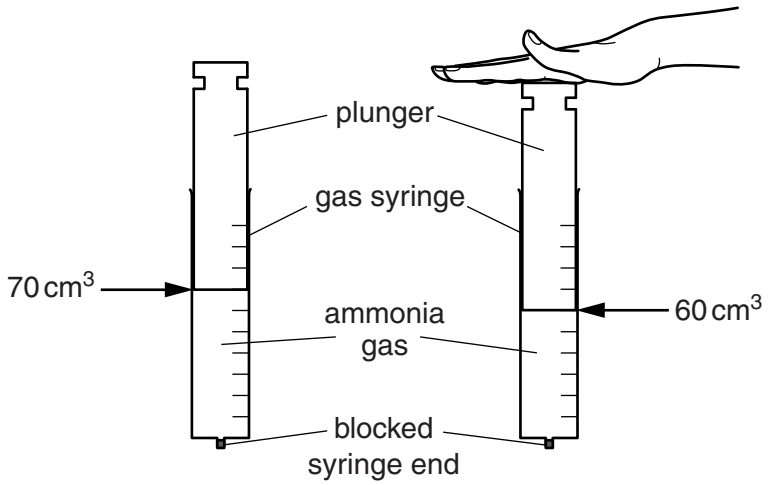
.....

.....

.....

.....[4]

(b) A gas syringe is filled with 70 cm^3 of ammonia gas.
The pressure on the plunger is increased.
The temperature does not change but the volume in the syringe decreases to 60 cm^3.



Use the kinetic particle theory to explain why the volume decreases.

.....

.....[1]

MARK SCHEME

1	(c)(i)	(net) movement of (any) particles or substance from high concentration to low concentration (1)	**1**
	(c)(ii)	fluorine has a lower (relative) molecular mass / fluorine molecules have less mass (1)	**1**
	(c)(iii)	(fluorine) molecules or particles move faster / (fluorine) molecules have more **kinetic** energy (1)	**1**

2	(f)(i)	volume increases **AND** particles move faster / particles spread out more / particles move further apart	**1**
	(f)(ii)	volume decreases **AND** particles move closer together / distance between particles decreases	**1**

3	(a)	any **three** from: • diffusion • particles move (from place to place) / particles collide • random (movement) of particles / particles go anywhere / particles (move) in all directions / particles disperse • intermingling of particles / mixing of particle • (bulk movement of ink particles) from higher to lower concentration	**3**

4	(a)	any **three** from: • evaporation • particles with highest kinetic energy escape the liquid / particle moving the fastest escape the liquid • diffusion • particles move (from place to place) / particles collide • random (movement) of particles / particles go anywhere / particles (move) in all directions / particles disperse • intermingling of particles / mixing of particles • (bulk movement of bromine particles) from higher to lower concentration	**3**

5	(d)	particles change from vibrational to translational motion / change from vibrations to moving very fast (1) change from a set pattern to a random arrangement (1) particles change from touching each other to large distance between particles (1)	**3**

6 **(b) (i)** Changing of a liquid into a gas / changing liquid to vapour (happening at any temperature) (1) **1**

(ii) Molecules have less energy / molecules move slower (1) **2**

Molecules don't have enough energy to overcome force between molecules / molecules don't have enough energy to escape (into the air) (1)

(a) **Pentyl** ethanoate / $CH_3CO_2C_5H_{11}$ (1) **2**

High**est** relative formula mass (1)

---

7 **(a)** **(i)** 1 mark each for any two of: **[2]**

- diffusion
- molecules move randomly / molecules spread out / molecules get mixed up
- (bulk movement of molecules) from high to low <u>concentration</u> / with the <u>concentration</u> gradient

(ii) they have different relative molecular masses / they have different molar masses (1) **[1]**

(b) molecules **or** particles move faster at higher temperature (or reverse argument) / molecules **or** particles have more (kinetic) energy at higher temperature (1) **[2]**

molecules spread out / molecules move further away from each other (on average) / space between molecules increases (1)

---

8 **(a)** **ANY FOUR FROM:** [4]

ammonia molecules / HBr molecules have enough energy to escape from the HBr(aq) or NH_3(aq) (1)

diffusion (1)

molecules move randomly / molecules spread out / molecules get mixed up (1)

move from high to low concentration / move with the concentration gradient (1)

solid formed where NH_3 and HBr react (1)

HBr has higher M_r than NH_3 / molecules of HBr are heavier than molecules of NH_3 (1)

NH_3 molecules move faster than HBr molecules / NH_3 diffuses faster (1)

(b) higher pressure pushes molecules closer together [1]

2.2 Atomic Structure & The Periodic Table

1 5070/22/M/J/23/Q4

This question is about compounds that contain magnesium and nitrogen.

(a) The formula for a nitride ion can be written as $^{15}_{7}N^{3-}$.

Complete Table 4.1 to show the number of particles in this nitride ion.

Table 4.1

particle	number of particles
electron	
neutron	
proton	

[3]

(b) State why the formula for a magnesium ion is Mg^{2+} rather than Mg^{+} or Mg^{3+}.

.....

..... [1]

(c) The formula for a nitride ion is N^{3-}.

Deduce the formula for magnesium nitride.

..... [1]

(d) Magnesium nitrate, $Mg(NO_3)_2$, is an ionic compound.

Predict **two** physical properties of magnesium nitrate.

1 .....

2 .....

[2]

---

2 5070/21/M/J/23/Q4

This question is about compounds that contain phosphorus.

(a) The formula for a phosphide ion can be written as $^{31}_{15}P^{3-}$.

Complete Table 4.1 to show the number of particles in this phosphide ion.

Table 4.1

particle	number of particles
electron	
neutron	
proton	

[3]

(b) State why the formula for a phosphide ion is P^{3-} rather than P^{2-} or P^{4-}.

.....

..... [1]

(c) The formula for a calcium ion is Ca^{2+}.

Deduce the formula for calcium phosphide.

..... [1]

(d) Calcium phosphate, $Ca_3(PO_4)_2$, is an ionic compound.

Explain why calcium phosphate has a high melting point.

.....

.....

..... [2]

3 5070/22/M/J/22/Q4

The table shows information about some particles.

particle	number of		
	protons	neutrons	electrons
$^{79}_{35}Br$	35	44	35
$^{79}_{35}Br^-$	35	44	
$^{40}_{20}Ca$	20	20	20
$^{40}_{20}Ca^{2+}$	20	20	18

(a) State the nucleon number for $^{79}_{35}Br$.

..... [1]

(b) State the number of electrons in $^{79}_{35}Br^-$.

..... [1]

(c) $^{40}_{20}Ca$ is the full symbol for one isotope of calcium.

Write the full symbol for one **other** isotope of calcium.

..... [1]

(d) Describe how a calcium ion, Ca^{2+}, is formed from a calcium atom, Ca.

..... [1]

4 5070/21/M/J/22/Q4

The table shows information about some particles.

particle	proton number	nucleon number
$^{35}_{17}Cl$	17	35
$^{35}_{17}Cl^-$	17	35
$^{39}_{19}K$	19	39
$^{39}_{19}K^+$	19	39

(a) State the number of neutrons in $^{35}_{17}Cl$.

..... [1]

(b) State the number of electrons in $^{35}_{17}Cl^-$.

..... [1]

---

5 5070/22/O/N/21/Q7(b)

(b) An ion of sodium has the symbol

$$^{23}_{11}Na^+$$

Deduce the number of protons, neutrons and electrons in this ion.

number of protons .....

number of neutrons .....

number of electrons .....

[3]

---

6 5070/21/O/N/21/Q7(b)

(b) An ion of silver has the symbol

$$^{109}_{47}Ag^+$$

Deduce the number of protons, neutrons and electrons in this ion.

number of protons .....

number of neutrons .....

number of electrons .....

[3]

---

7 5070/22/O/N/20/Q9(a)

Lead is a metal in Group IV of the Periodic Table.

(a) An ion of lead has the symbol

$$^{207}_{82}Pb^{2+}$$

Deduce the number of electrons and neutrons in this ion.

number of electrons .....

number of neutrons .....

[2]

---

8 5070/21/O/N/20/Q9(b)

(b) An ion of calcium has the symbol

$$^{44}_{20}Ca^{2+}$$

Deduce the number of electrons and neutrons in this ion.

number of electrons .....

number of neutrons .....

[2]

---

9 5070/22/M/J/20/Q7(a)

This question is about some of the oxides of the elements in Period 3.

(a) State the electronic configuration of the negative ion in sodium oxide, Na_2O.

..... [1]

---

10 5070/21/M/J/20/Q8(a)

This question is about the chlorides of the elements in Period 3.

(a) State the electronic configuration of the positive ion in sodium chloride, NaC*l*.

..... [1]

---

11 5070/22/O/N/19/Q8(a-i)

Phosphorus is an element in Group V of the Periodic Table.

(a) One of the isotopes of phosphorus is:

$$^{31}_{15}P$$

(i) Deduce the number of electrons, neutrons and protons in this isotope of phosphorus.

number of electrons .....

number of neutrons .....

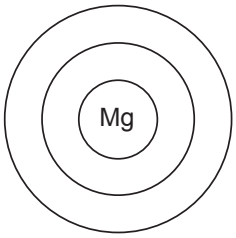
number of protons .....

[3]

---

12 5070/22/O/N/19/Q2(b)

(b) Complete the electronic configuration of a magnesium atom. Show all electrons.



[1]

---

13 5070/21/O/N/19/Q8(a)

Silicon is an element in Group IV of the Periodic Table.

(a) One of the isotopes of silicon is:

$$^{30}_{14}Si$$

Deduce the number of electrons, neutrons and protons in one atom of this isotope of silicon.

number of electrons .....

number of neutrons .....

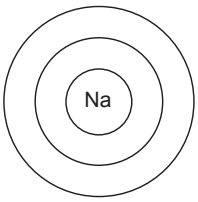
number of protons .....

[3]

---

14 5070/21/O/N/19/Q2(b)

(b) Complete the electronic configuration of a sodium atom. Show all electrons.



[1]

---

15 5070/21/M/J/19/Q2(c-i)

(c) Magnesium chloride contains Mg^{2+} and Cl^- ions.

(i) Write the electronic configuration for a magnesium ion.

..... [1]

---

16 5070/22/M/J/18/Q4(d)

(d) Complete the table about the number of electrons, neutrons and protons in two particles.

particle	$^{30}_{15}P$	.....
number of electrons	.....	18
number of neutrons	.....	16
number of protons	.....	15

[2]

---

17 5070/22/O/N/18/Q5(b)

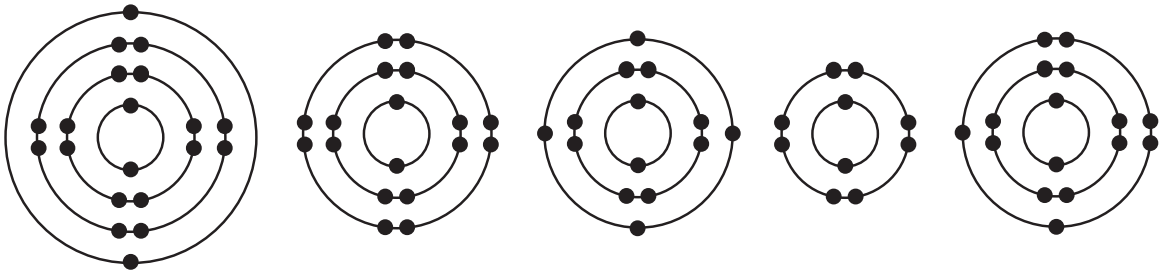
(b) Phosphorus is an element in Group V of the Periodic Table.
Deduce the electronic configuration of a phosphide ion, P^{3-}.

.....[1]

---

18 5070/22/O/N/18/Q1

The electronic configurations of five atoms are shown.



A B C D E

(a) Which electronic configuration represents each of the following descriptions?
Each electronic configuration may be used once, more than once or not at all.

(i) a sulfur atom

.....[1]

(ii) a metal atom

.....[1]

(iii) an atom with a proton number of 14

.....[1]

(iv) an atom of a noble gas with three occupied electron shells

.....[1]

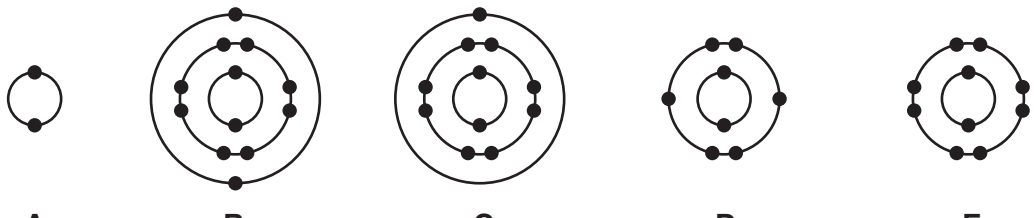
(v) an atom which forms a noble gas electronic configuration when it loses two electrons

.....[1]

---

19 5070/21/O/N/18/Q1

The electronic configurations of five atoms are shown.



A **B** **C** **D** **E**

(a) Which electronic configuration represents each of the following descriptions?
Each electronic configuration may be used once, more than once or not at all.

(i) a sodium atom

.....[1]

(ii) an atom of a reactive non-metallic element

.....[1]

(iii) an atom with a proton (atomic) number of 12

.....[1]

(iv) an atom of a noble gas which is used to fill balloons

.....[1]

(v) an atom which forms a noble gas electronic configuration when it gains two electrons

.....[1]

20 5070/22/M/J/17/Q4(a)

Sodium oxide, Na_2O, is an ionic compound.

(a) State the electronic configuration for each of the ions in sodium oxide.

sodium ion .....

oxide ion .....

[2]

21 5070/22/M/J/17/Q2(a)

The table shows some information about six particles.

(a) Complete the table.

particle	proton (atomic) number	number of neutrons in particle	number of electrons in particle
^{35}Cl	17	18	.....
.....	17	20	17
$^{39}K^+$	19	.....	18
$^{79}Br^-$	.....	44	36
^{81}Br	35	.....	35
.....	37	48	36

[6]

22 5070/21/M/J/17/Q4(a)

Calcium chloride, $CaCl_2$, is an ionic compound.

(a) State the electronic configuration for each of the ions in calcium chloride.

calcium ion .....

chloride ion .....

[2]

23 5070/21/M/J/17/Q2(a)

(a) Atoms and ions contain three types of sub-atomic particle.

Complete the table about these sub-atomic particles.

sub-atomic particle	relative charge	relative mass
electron		
neutron		1
proton	+1	

[3]

(b) The table shows some information about six particles.

particle	number of protons in particle	number of neutrons in particle	number of electrons in particle
A	37	48	37
B	53	74	54
C	92	143	92
D	92	143	89
E	92	146	92
F	94	150	92

(i) What is the nucleon number for particle **A**?

.....[1]

(ii) Explain why particle **B** is a negative ion.

.....[1]

(iii) Which two **atoms** are isotopes of the same element?

..... and .....

Explain your answer.

.....

.....

[2]

24 5070/22/O/N/16/Q5/d

The proton numbers and accurate relative atomic masses of cobalt and nickel are shown in the table.

	cobalt	nickel
proton number	27	28
relative atomic mass	58.9	58.7

Suggest why cobalt has a higher relative atomic mass than nickel.

.....

.....

.....[2]

---

25 5070/22/O/N/16/Q4/c/d

(a) Iodine has several isotopes.
What are isotopes?

.....

.....[1]

(b) Astatine, At, is a halogen.
Aqueous iodine reacts with aqueous astatide ions, At^-, to produce astatine.
Construct the ionic equation for this reaction.

.....[1]

---

26 5070/21/O/N/16/Q6

Dry air contains nitrogen, oxygen, argon and other gases.

(a) State the percentage compositions by volume of nitrogen and oxygen present in dr y air.

nitrogen ..... % oxygen ..... % [1]

(b) The formula for oxygen gas is O_2.

(i) Draw a 'dot-and-cross' diagram of an oxygen molecule.

Show only the outer shell electrons.

[1]

(ii) What is the formula of argon gas?

.....[1]

---

27 5070/22/M/J/16/Q6

River water contains dissolved minerals and gases.

(a) Carbon dioxide is one of the gases dissolved in river water.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of carbon dioxide. Only draw the outer-shell electrons.

[1]

28 5070/22/M/J/15/Q3

Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

difference .....

.....

similarity .....

.....

[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.

Suggest the formula of a phosphorus molecule.

.....[1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

.....[1]

(ii) Explain why phosphorus does not conduct electricity.

.....[1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	……
number of protons	……
electronic configuration	……

[3]

(e) Phosphorus forms a compound called phosphine, PH_3.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of phosphine.

Only draw the outer shell electrons.

[2]

(f) Phosphine ignites in air to make water and phosphorus(V) oxide.

Construct the equation for this reaction.

.....[2]

29 5070/21/M/J/15/Q4

Two isotopes of sulfur are $^{32}_{16}S$ and $^{33}_{16}S$.

(a) What is meant by the term *isotopes*?

.....[1]

(b) Complete the table for $^{33}_{16}S$.

number of neutrons	……
number of protons	……
electronic configuration	……

[3]

(c) Sulfur forms simple molecules which have a relative molecular mass of 256.

Suggest the formula of a sulfur molecule.

.....[1]

(d) Sulfur has a low melting point and does not conduct electricity.

(i) Explain why sulfur has a low melting point.

.....[1]

(ii) Explain why sulfur does not conduct electricity.

.....[1]

(e) Sulfur reacts with potassium to form potassium sulfide.

Write the formula and the electronic configuration of the positive ion and of the negative ion in potassium sulfide.

positive ion

formula ..... electronic configuration .....

negative ion

formula ..... electronic configuration .....

[2]

(f) Sulfur reacts with hydrogen to form hydrogen sulfide, H_2S.

Draw the 'dot-and-cross' diagram to show the bonding in a molecule of hydrogen sulfide.

Only draw the outer shell electrons.

[2]

(g) Hydrogen sulfide reacts with sulfur dioxide to form sulfur and water.

Write the equation for this reaction.

.....[1]

30 5070/22/M/J/15/Q3

Two isotopes of phosphorus are $^{31}_{15}P$ and $^{32}_{15}P$.

(a) State one difference and one similarity between these two isotopes.

difference

.....

similarity

.....

.....

[2]

(b) Phosphorus forms simple molecules which have a relative molecular mass of 124.
Suggest the formula of a phosphorus molecule.

.....[1]

(c) Phosphorus has a low melting point and does not conduct electricity.

(i) Explain why phosphorus has a low melting point.

.....[1]

(ii) Explain why phosphorus does not conduct electricity.

.....[1]

(d) Complete the table for $^{31}_{15}P^{3-}$.

number of neutrons	……
number of protons	……
electronic configuration	……

[3]

31 5070/22/M/J/14/Q10

Astatine, At, is an element in Group VII of the Periodic Table.
The table shows some information about two isotopes of astatine.

symbol	number of protons	number of electrons	number of neutrons
$^{210}_{85}At$	.....	.....	.....
$^{211}_{85}At$	.....	.....	.....

(a) (i) Complete the table. [2]

(ii) What is meant by the term *isotopes*?

.....

.....[1]

MARK SCHEME

1 (a) **3**

particle	number of particles
electron	**10** (1)
neutron	**8** (1)
proton	**7** (1)

(b) Mg^{2+} has full outer shell (of electrons) (1) **1**

(c) Mg_3N_2 (1) **1**

(d) soluble in water / dissolves in water(1) **2**
conducts electricity in (aqueous) solution (1)

---

2 (a) **3**

particle	number of particles
electron	**18** (1)
neutron	**16** (1)
proton	**15** (1)

(b) P^{3-} has full outer shell of electrons (1) **1**

(c) Ca_3P_2 (1) **1**

(d) giant structure (1) **2**
strong attraction between positive and negative **ions** /
strong electrostatic attraction between **ions** (1)

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3 (a) 79 **1**

(b) 36 **1**

(c) $^{41}_{20}Ca$ **1**

(d) loses **two** electrons **1**

---

4 (a) 18 **1**

(b) 18 **1**

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5 (b) protons: 11 (1) **3**

neutrons: 12 (1)

electrons: 10 (1)

6 (b) protons: **47** (1)
neutrons: **62** (1)
electrons: **46** (1) **3**

7 (a) electrons = 80 (1)
neutrons = 125 (1) **2**

8 (b) electrons:18 (1)
neutrons: 24 (1) **2**

9 (a) 2.8 **1**

10 (a) 2.8 **1**

11 (a)(i) *electrons*: 15 (1)
neutrons: 16 (1)
protons: 15 (1) **3**

12 (b) electronic structure of 2.8.2 **1**

13 (a) *electrons*: 14 (1)
neutrons: 16 (1)
protons: 14 (1) **3**

14 (b) drawing of electronic structure of 2.8.1 **1**

15 (c)(i) 2.8 (1) **1**

16 (d) **2**

particle	$^{30}_{15}P$	$^{31}_{15}P^{3-}$
number of electrons	**15**	18
number of neutrons	**15**	16
number of protons	**15**	15
	(1)	(1)

17 (b) 2.8.8 **1**

18 (a)(i) E **1**

(a)(ii) A **1**

(a)(iii) C **1**

(a)(iv) B **1**

(a)(v) A **1**

19 (a)(i) C **1**

(a)(ii) D **1**

(a)(iii) B **1**

(a)(iv) A **1**

(a)(v) D **1**

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20 (a) Sodium ion: 2.8 (1)
Oxide ion: 2.8 (1) **2**

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21 (a) **6**

particle	atomic number	number of neutrons in particle	number of electrons in particle
^{35}Cl	17	18	**17** (1)
^{37}Cl (1)	17	20	17
$^{39}K^{+}$	19	**20** (1)	18
$^{79}Br^{-}$	**35** (1)	44	36
^{81}Br	35	**46** (1)	35
$^{85}Rb^{+}$ (1)	37	48	36

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22 (a) Calcium ion is 2.8.8 (1)
Chloride ion is 2.8.8 (1) **2**

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23 (a) **3**

sub-atomic particle	relative electric charge	relative mass
electron	**–1**	**0 / 0.0005**
neutron	**0**	1
proton	+1	**1**

All four correct (3)
Three correct (2)
Two correct (1)
One correct (0)

(b)(i) 85 **1**

(b)(ii) Has more electrons than protons **1**

(b)(iii) **C** and **E** (1) **2**

Same number of protons but different number of neutrons (1)

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24 isotopes (1) **2**

cobalt has greater proportion of heavier isotopes than nickel/nickel has lower proportion of lighter isotopes than nickel (1)

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25 **(a)** atom(s) with same number of protons and different number of neutrons/atom(s) of the same element with different number of neutrons (1) **1**

(b) $I_2 + 2At^- \rightarrow At_2 + 2I^-$ (1) **1**