Atoms, Elements and Compounds – 2021 IGCSE 0620

1. June/2021/Paper_11,12,13,21,22&23/No.4

Element X has 7 protons.

Element Y has 8 more protons than X.

Which statement about element Y is correct?

A Y has more electron shells than X.

B Y has more electrons in its outer shell than X.

C Y is in a different group of the Periodic Table from X.

D Y is in the same period of the Periodic Table as X.

2. June/2021/Paper_11,12,13,21,22&23/No.5

A covalent molecule Q contains only six shared electrons.

What is Q?

A ammonia, NH_3

B chlorine, Cl_2

C methane, CH_4

D water, H_2O

3. June/2021/Paper_11/No.6

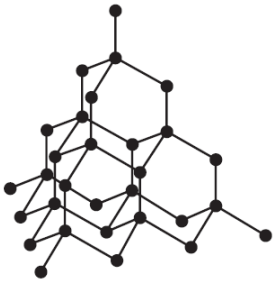
Which row describes how an ionic bond forms between a sodium atom and a chlorine atom?

	sodium atom	chlorine atom
A	two electrons are lost	two electrons are gained
B	one electron is gained	one electron is lost
C	two electrons are gained	two electrons are lost
D	one electron is lost	one electron is gained

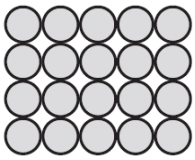
4. June/2021/Paper_11/No.7

Which diagram shows the structure of an alloy?

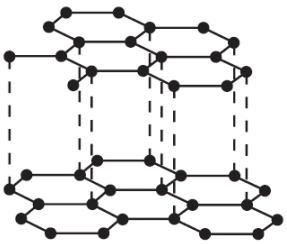
A



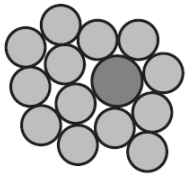
B



C



D



5. June/2021/Paper_12/No.6

What is the formula of the product of burning sodium in chlorine gas?

A $NaCl$ **B** Na_2Cl **C** $NaCl_2$ **D** Na_2Cl_2

6. June/2021/Paper_12/No.7

Chemical compounds formed from a Group I element and a Group VII element contain ionic bonds.

How are the ionic bonds formed?

A Electrons are transferred from Group VII atoms to Group I atoms.

B Electrons are shared between Group I atoms and Group VII atoms.

C Electrons are lost by Group I atoms and Group VII atoms.

D Electrons are transferred from Group I atoms to Group VII atoms.

7. June/2021/Paper_12/No.8

Some information about particles P, Q, R and S is shown.

	nucleon number	number of neutrons	number of electrons
P	12	6	6
Q	24	12	10
R	16	8	10
S	14	8	6

Which two particles are isotopes of the same element?

A P and Q **B** P and S **C** Q and R **D** R and S

8. June/2021/Paper_13/No.7

Which statement about isotopes of the same element is correct?

A They have different numbers of electrons.

B They have different numbers of neutrons.

C They have different numbers of protons.

D They have the same mass number.

9. June/2021/Paper_13/No.8

Potassium reacts with iodine to form an ionic compound.

$$2K + I_2 \rightarrow 2KI$$

Which statements describe what happens when potassium reacts with iodine?

1 Each potassium atom loses two electrons.

2 Each potassium atom loses one electron.

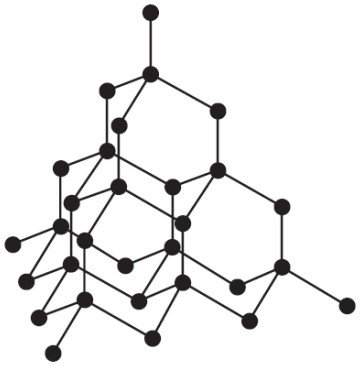
3 Each iodine atom gains one electron.

4 Each iodine atom gains two electrons.

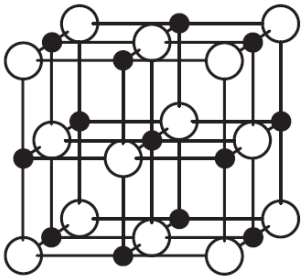
A 1 and 3 **B** 1 and 4 **C** 2 and 3 **D** 2 and 4

10. June/2021/Paper_21/No.6

The arrangement of particles in each of two solids, S and T, are shown.



S



T

What are S and T?

	S	T
A	diamond	silicon(IV) oxide
B	diamond	sodium chloride
C	graphite	silicon(IV) oxide
D	graphite	sodium chloride

11. June/2021/Paper_21/No.7

Which statement about metals is correct?

A Metals conduct electricity when molten because negative ions are free to move.

B Metals conduct electricity when solid because positive ions are free to move.

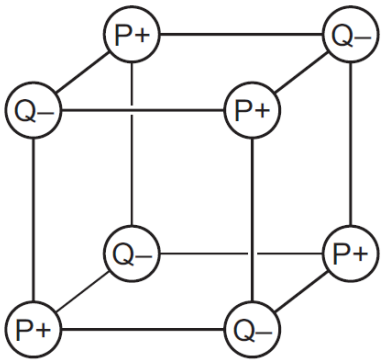
C Metals are malleable because the bonds between the atoms are weak.

D Metals are malleable because the layers of ions can slide over each other.

12. June/2021/Paper_21/No.8

Two elements, P and Q, are in the same period of the Periodic Table.

P and Q react together to form an ionic compound. Part of the lattice of this compound is shown.



Which statement is correct?

A An ion of P has more electrons than an ion of Q.

B Element P is non-metallic.

C P is to the left of Q in the Periodic Table.

D The formula of the compound is P_4Q_4.

13. June/2021/Paper_22/No.6

Information about four substances E, F, G and H is shown.

	melting point / °C	electrical conductivity
E	1710	does not conduct when solid
F	3500	conducts when solid
G	120	does not conduct
H	801	conducts when molten

E, F, G and H are graphite, poly(ethene), sodium chloride and silicon(IV) oxide but not in that order.

What are E, F, G and H?

	E	F	G	H
A	graphite	poly(ethene)	silicon(IV) oxide	sodium chloride
B	sodium chloride	graphite	poly(ethene)	silicon(IV) oxide
C	poly(ethene)	sodium chloride	graphite	silicon(IV) oxide
D	silicon(IV) oxide	graphite	poly(ethene)	sodium chloride

14. June/2021/Paper_22/No.7

Chemical compounds formed from a Group I element and a Group VII element contain ionic bonds.

How are the ionic bonds formed?

A Electrons are transferred from Group VII atoms to Group I atoms.

B Electrons are shared between Group I atoms and Group VII atoms.

C Electrons are lost by Group I atoms and Group VII atoms.

D Electrons are transferred from Group I atoms to Group VII atoms.

15. June/2021/Paper_22/No.8

Some information about particles P, Q, R and S is shown.

	nucleon number	number of neutrons	number of electrons
P	12	6	6
Q	24	12	10
R	16	8	10
S	14	8	6

Which two particles are isotopes of the same element?

A P and Q **B** P and S **C** Q and R **D** R and S

16. June/2021/Paper_23/No.6

Which statement explains why metals are malleable?

A The atoms release electrons to become cations.

B The electrons are free to move.

C The electrons and the cations are attracted to each other.

D The layers of ions can slide over each other.

17. June/2021/Paper_23/No.7

Which statement about isotopes of the same element is correct?

A They have different numbers of electrons.

B They have different numbers of neutrons.

C They have different numbers of protons.

D They have the same mass number.

18. June/2021/Paper_23/No.8

The element silicon has the same structure as diamond.

Which statement about silicon is correct?

A Every silicon atom is bonded to three other atoms only.

B Silicon has a high melting point.

C Silicon is a good conductor of electricity.

D Silicon is used as a lubricant.

19. June/2021/Paper_23/No.9

Three ionic compounds of vanadium have the formulae V_2O, VCl_2 and V_2O_3.

What is the charge on the vanadium ion in each compound?

	V_2O	VCl_2	V_2O_3
A	+1	–2	+2
B	+1	+2	+3
C	+2	–2	+2
D	+2	+2	+3

20. March/2021/Paper_12/No.5

A neutral atom, J, contains 45 neutrons and 35 electrons.

Which row is correct for atom J?

	proton number	nucleon number
A	35	45
B	35	80
C	45	45
D	45	80

21. March/2021/Paper_12&22/No.6

Lithium and fluorine react to form lithium fluoride.

A student writes three statements about the reaction.

1 Lithium atoms lose an electron when they react.

2 Each fluoride ion has one more electron than a fluorine atom.

3 Lithium fluoride is a mixture of elements.

Which statements are correct?

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 1, 2 and 3

22. March/2021/Paper_12/No.7

Which definition of isotopes is correct?

A atoms of the same element that have the same number of electrons and nucleons

B atoms of the same element that have the same number of neutrons and protons

C atoms of the same element that have the same number of protons but a different number of electrons

D atoms of the same element that have the same number of protons but a different number of nucleons

23. March/2021/Paper_12/No.8

In which molecule are all the outer shell electrons from each atom used to form covalent bonds?

A CH_4 **B** Cl_2 **C** H_2O **D** NH_3

24. March/2021/Paper_12/No.9

What is the balanced chemical equation for the reaction between calcium and water?

A $Ca + H_2O \rightarrow CaOH + H_2$

B $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

C $Ca + 2H_2O \rightarrow CaOH + H_2$

D $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

25. March/2021/Paper_22/No.4

Which statement about the atoms of all the isotopes of carbon is correct?

A They are all radioactive.

B They have the same mass.

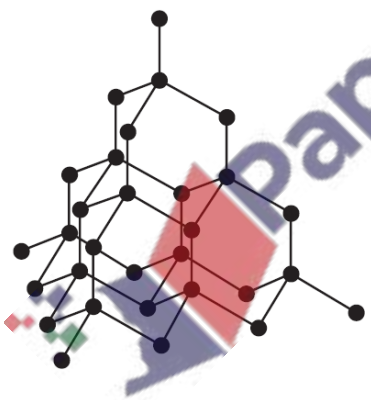
C They have the same number of neutrons.

D They have the same number of electrons in the outer shell.

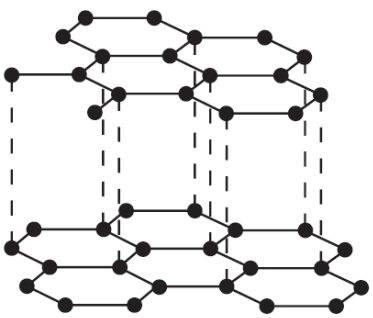
26. March/2021/Paper_22/No.5

Which diagram represents the structure of silicon(IV) oxide?

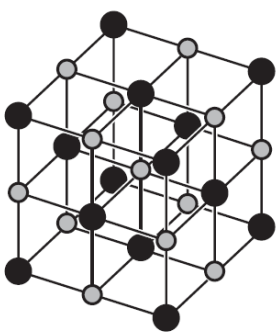
A



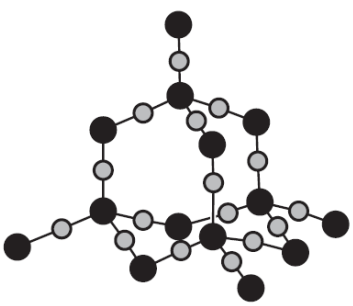
B



C



D



27. March/2021/Paper_22/No.6

How many electrons are used to form covalent bonds in a molecule of methanol, CH_3OH?

A 5 **B** 6 **C** 8 **D** 10

28. March/2021/Paper_22/No.7

Magnesium oxide has a high melting point.

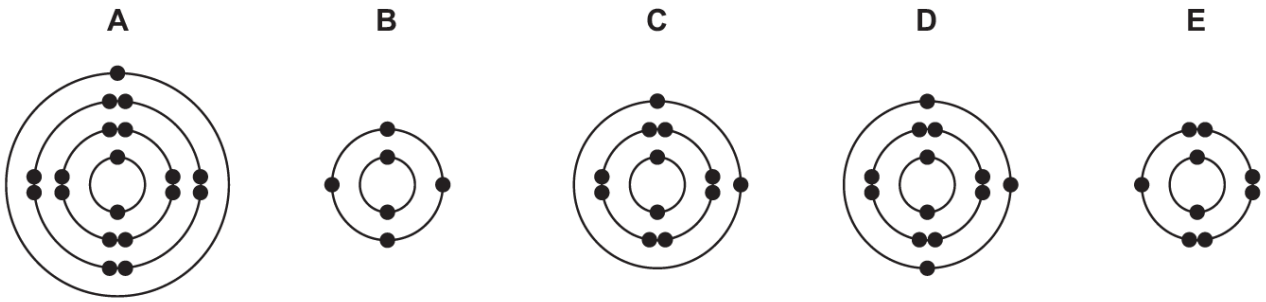
Carbon dioxide has a low melting point.

Which row identifies the attractive forces that are broken when these compounds are melted?

	magnesium oxide	carbon dioxide
A	strong attractions between molecules	weak attractions between atoms
B	strong attractions between molecules	weak attractions between molecules
C	strong attractions between ions	weak attractions between atoms
D	strong attractions between ions	weak attractions between molecules

29. June/2021/Paper_31/No.1

(a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group II of the Periodic Table

..... [1]

(ii) an atom with a proton number of 13

..... [1]

(iii) an atom that forms a stable ion with a single negative charge

..... [1]

(iv) an atom of a non-metal that forms a giant covalent structure

..... [1]

(v) an atom of a metal used in food containers.

..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the vanadium atom and calcium ion shown.

	number of electrons	number of neutrons	number of protons
$^{51}_{23}V$	23		
$^{48}_{20}Ca^{2+}$		28	

[3]

[Total: 8]

30. June/2021/Paper_31/No.3

The table shows some properties of four Group I elements.

element	melting point /°C	boiling point /°C	atomic radius /nm
sodium	98	883	0.191
potassium	63	760	
rubidium	39		0.250
caesium	29	671	0.272

(a) (i) Complete the table by predicting:
- the boiling point of rubidium
- the atomic radius of potassium.

[2]

(ii) Describe the trend in the melting point of the Group I elements down the group.

..... [1]

(iii) Deduce the physical state of potassium at 60 °C.
Explain your answer.

.....

.....

..... [2]

(b) Caesium is a radioactive element with a proton number of 55.

(i) Define proton number.

..... [1]

(ii) State **one** industrial use of radioactive isotopes.

..... [1]

(c) Sodium hydride, NaH, reacts with iron(III) oxide.

(i) Balance the equation for this reaction.

$$Fe_2O_3 + 3NaH \rightarrow .....Fe + ...NaOH$$ [2]

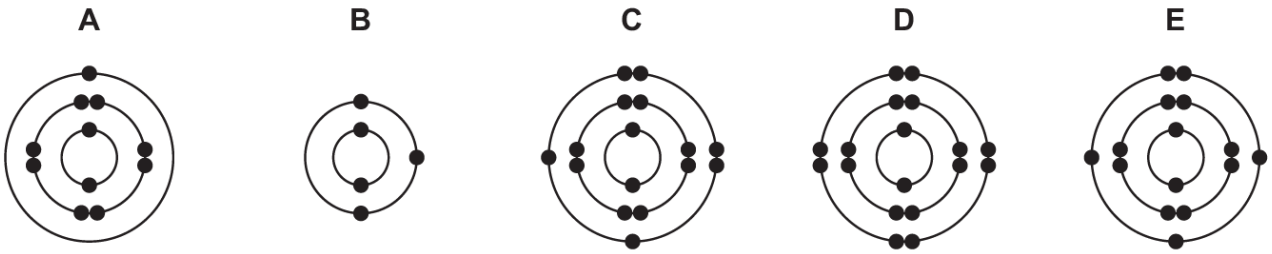
(ii) Explain how this equation shows that iron(III) oxide is reduced.

..... [1]

[Total: 10]

31. June/2021/Paper_32/No.1

(a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom in Group III of the Periodic Table

..... [1]

(ii) an atom of a noble gas

..... [1]

(iii) an atom that forms a stable ion with a single positive charge

..... [1]

(iv) an atom that contains only two shells of electrons

..... [1]

(v) an atom with a proton number of 16.

..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the silicon atom and sodium ion shown.

	number of electrons	number of neutrons	number of protons
$^{30}_{14}Si$	14		
$^{23}_{11}Na^{+}$		12	

[3]

[Total: 8]

32. June/2021/Paper_32/No.3

The table shows some properties of four halogens.

element	melting point / °C	boiling point / °C	density of liquid at boiling point in g / cm^3	colour
chlorine	–101	–35	1.56	light green
bromine	–7		3.12	red-brown
iodine	114	184		dark grey
astatine	302	337	6.35	black

(a) (i) Complete the table by predicting:

- the boiling point of bromine
- the density of liquid iodine at its boiling point.

[2]

(ii) Describe the trend in the depth of colour of the halogens down the group.

..... [1]

(iii) Deduce the state of chlorine at –50 °C.
Explain your answer.

.....

.....

..... [2]

(b) The halogens have molecules that are diatomic.

Explain the meaning of the term *diatomic*.

..... [1]

(c) Astatine is a radioactive element. One isotope of astatine has a nucleon number of 209.

(i) Define *nucleon number*.

..... [1]

(ii) State **one** medical use of radioactive isotopes.

..... [1]

(iii) The isotope ^{235}U is also radioactive.

State the major use of this isotope of uranium.

..... [1]

[Total: 9]

33. June/2021/Paper_32/No.7

(a) Dilute sulfuric acid is electrolysed using carbon electrodes.

State the products of this electrolysis at:

the negative electrode .....

the positive electrode. .....

[2]

(b) Graphite is a form of carbon. Graphite has a giant structure with covalent bonds.

(i) State the meaning of the term *covalent bond*.

.....

..... [2]

(ii) Graphite is a solid.

Describe the arrangement and motion of the particles in a solid.

arrangement .....

.....

motion .....

.....

[2]

(c) Graphite is one form of solid carbon.

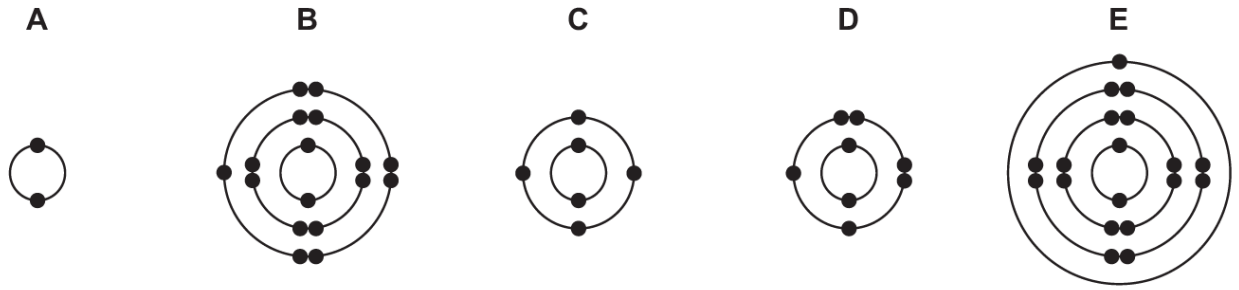
Name one **other** form of solid carbon.

..... [1]

[Total: 7]

34. June/2021/Paper_33/No.1

(a) The electronic structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown.



Answer the following questions about these electronic structures.
Each electronic structure may be used once, more than once or not at all.

State which electronic structure, **A**, **B**, **C**, **D** or **E**, represents:

(i) an atom of an element in Group VI of the Periodic Table

..... [1]

(ii) an atom of a reactive metal

..... [1]

(iii) an atom with a proton number of 17

..... [1]

(iv) an atom that forms a stable ion with a charge of 2–

..... [1]

(v) an atom of oxygen.

..... [1]

(b) Complete the table to show the number of electrons, neutrons and protons in the bromine atom and fluoride ion shown.

	number of electrons	number of neutrons	number of protons
$^{81}_{35}Br$	35		
$^{19}_{9}F^-$		10	

[3]

[Total: 8]

35. June/2021/Paper_33/No.3

The table shows some properties of five halogens.

element	melting point /°C	boiling point /°C	density of liquid at boiling point in g/cm^3	colour
fluorine	–220	–188		yellow
chlorine		–35	1.56	light green
bromine	–7	59	3.12	red-brown
iodine	114	184	4.93	dark grey
astatine	302	337	6.35	

(a) (i) Complete the table by predicting:

- the melting point of chlorine
- the density of liquid fluorine at its boiling point
- the colour of astatine.

[3]

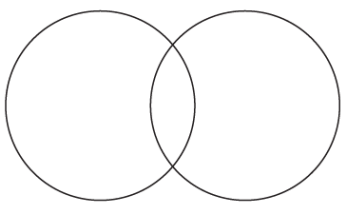
(ii) Deduce the state of bromine at 0 °C.
Explain your answer.

.....

.....

..... [2]

(b) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of chlorine.
Show the outer shell electrons only.



[2]

(c) (i) Astatine is a radioactive element.

An isotope of astatine, $^{217}_{85}At$, decays to form an isotope of bismuth, $^{213}_{83}Bi$.

Describe what happens to the number of nucleons during this decay.

..... [1]

(ii) One of these statements about isotopes is **incorrect**.

Tick the box with the incorrect statement.

The isotope ^{235}U is a source of energy.	☐
Some radioactive isotopes can be used to treat cancer.	☐
All isotopes are radioactive.	☐
Isotopes of the same element have the same number of protons.	☐

[1]

[Total: 9]

36. June/2021/Paper_41/No.2

Complete the table to:

- deduce the number of protons, electrons and neutrons in the magnesium atom and copper ion shown
- identify the atom or ion represented by the final row.

	number of protons	number of electrons	number of neutrons
$^{25}_{12}Mg$	12		
$^{65}_{29}Cu^{2+}$			36
	17	18	20

[Total: 5]

37. June/2021/Paper_41/No.3

Potassium reacts with chlorine to form potassium chloride, KC*l*.

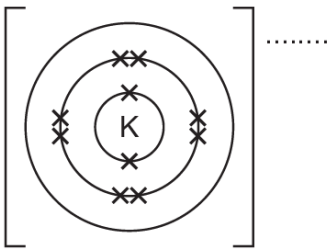
(a) Write a chemical equation for this reaction.

..... [2]

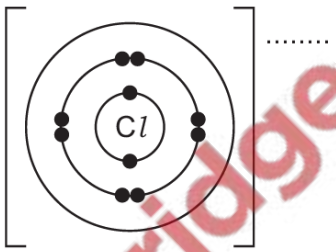
(b) Potassium chloride is an ionic compound.

Complete the diagram to show the electron arrangement in the outer shells of the ions present in potassium chloride.

Give the charges on both ions.



.....



.....

[3]

(c) Molten potassium chloride undergoes electrolysis.

(i) State what is meant by the term *electrolysis*.

.....

..... [2]

(ii) Name the products formed at the positive electrode (anode) and negative electrode (cathode) when molten potassium chloride undergoes electrolysis.

anode .....

cathode .....

[2]

(d) Concentrated aqueous potassium chloride undergoes electrolysis.

(i) Write an ionic half-equation for the reaction at the negative electrode (cathode).

..... [2]

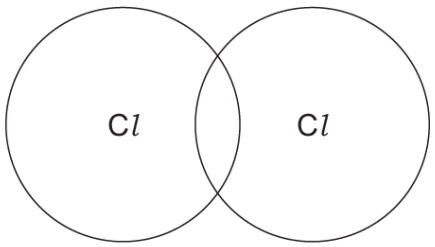
(ii) Name the product formed at the positive electrode (anode).

..... [1]

(iii) Name the potassium compound that remains in the solution after electrolysis.

..... [1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of chlorine, Cl_2.
Show the outer electrons only.



[1]

(f) The melting points and boiling points of chlorine and potassium chloride are shown.

	melting point / °C	boiling point / °C
chlorine	–101	–35
potassium chloride	770	1500

(i) Deduce the physical state of chlorine at –75 °C. Use the data in the table to explain your answer.

physical state .....

explanation .....

.....

[2]

(ii) Explain, in terms of structure and bonding, why potassium chloride has a much higher melting point than chlorine.

Your answer should refer to the:

- types of particle held together by the forces of attraction
- types of forces of attraction between particles
- relative strength of the forces of attraction.

.....

.....

.....

.....

..... [3]

[Total: 19]

38. June/2021/Paper_42/No.5

This question is about compounds of nitrogen.

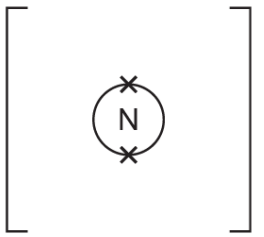
(a) Nitrogen reacts with lithium to form lithium nitride, Li_3N.

(i) Write the chemical equation for the reaction between lithium and nitrogen.

..... [2]

(ii) Lithium nitride is ionically bonded.

Complete the diagram to show the electronic structure of the nitride ion.
Show the charge on the nitride ion.



.....

[2]

(b) Nitrogen reacts with fluorine to form nitrogen trifluoride, NF_3.

(i) The chemical equation can be represented as shown.

$$N{\equiv}N + 3\ F{-}F \rightarrow 2\ F{-}\underset{\displaystyle F}{\underset{|}{N}}{-}F$$

Some bond energies are shown in the table.

bond	bond energy in kJ / mol
N≡N	945
F–F	160
N–F	300

Calculate the energy change for the reaction between nitrogen and fluorine, using the following steps:

- energy taken in to break bonds

..... kJ

- energy released when bonds are formed

..... kJ

- energy change during the reaction.

..... kJ / mol
[3]

(ii) Use your answer to **(i)** to deduce whether this reaction is endothermic or exothermic. Explain your answer.

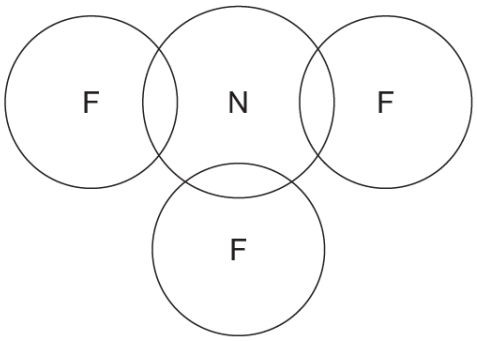
.....

..... [1]

(iii) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of NF_3.

Use dots for nitrogen electrons and crosses for fluorine electrons.

Show outer electrons only.



[3]

(c) Lithium nitride melts at 813 °C. Nitrogen trifluoride melts at –206 °C.

Explain in terms of attractive forces why lithium nitride has a much higher melting point than nitrogen trifluoride.

In your answer refer to the types of attractive forces between particles and their relative strengths.

.....

.....

.....

..... [3]

(d) Ammonium nitrate, NH_4NO_3, is a compound of nitrogen.

(i) Calculate the percentage by mass of nitrogen in ammonium nitrate.

percentage by mass of nitrogen = ... [2]

(ii) State a use of ammonium nitrate in agriculture.

..... [1]

(iii) State the name of a compound that will displace ammonia from ammonium nitrate.

..... [1]

(e) Ammonia is a base which forms a weakly alkaline solution when dissolved in water.

(i) Define the term *base*.

..... [1]

(ii) Suggest the pH of aqueous ammonia.

..... [1]

[Total: 20]

39. June/2021/Paper_43/No.2

Complete the table to:

- deduce the number of protons, electrons and neutrons in the boron atom and chloride ion shown
- identify the atom or ion represented by the final row.

formula	number of protons	number of electrons	number of neutrons
$^{11}_{5}B$		5	
$^{35}_{17}Cl^{-}$	17		
	24	21	30

[Total: 5]

40. June/2021/Paper_43/No.3

Sodium reacts with fluorine to form sodium fluoride, NaF.

(a) Write a chemical equation for this reaction.

..... [2]

(b) Sodium fluoride is an ionic compound.

Complete the diagram to show the electron arrangement in the outer shells of the ions present in sodium fluoride.

Give the charges on both ions.

[3]

(c) Aqueous sodium fluoride undergoes electrolysis.

(i) State what is meant by the term *electrolysis*.

.....

..... [2]

(ii) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when dilute aqueous sodium fluoride undergoes electrolysis.

anode .....

cathode .....

[2]

(d) Molten sodium fluoride undergoes electrolysis.

(i) Name the products formed at the positive electrode (anode) and the negative electrode (cathode) when molten sodium fluoride undergoes electrolysis.

anode .....

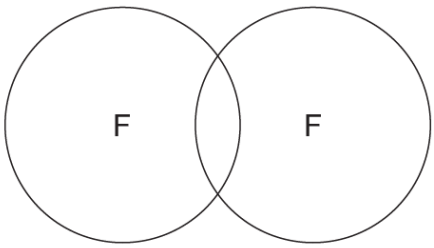
cathode .....

[2]

(ii) Write the ionic half-equation for the reaction at the negative electrode (cathode).

..... [1]

(e) Complete the dot-and-cross diagram to show the electron arrangement in a molecule of fluorine, F_2.
Show the outer electrons only.



[1]

(f) The melting points and boiling points of fluorine and sodium fluoride are shown.

	melting point / °C	boiling point / °C
fluorine	–220	–188
sodium fluoride	993	1695

(i) Deduce the physical state of fluorine at –195 °C. Use the data in the table to explain your answer.

physical state .....

explanation .....

.....

[2]

(ii) Explain, in terms of structure and bonding, why sodium fluoride has a much higher melting point than fluorine.

Your answer should refer to the:

- types of particle held together by the forces of attraction
- types of forces of attraction between particles
- relative strength of the forces of attraction.

.....

.....

.....

..... [3]

[Total: 18]

41. March/2021/Paper_32/No.2

The table shows the mass of some of the ions in a 1000 cm^3 sample of sea water.

name of ion	formula of ion	mass of ion in 1000 cm^3 of sea water / mg
bromide	Br^-	65
calcium	Ca^{2+}	400
chloride	Cl^-	18 980
hydrogencarbonate	HCO_3^-	140
magnesium	Mg^{2+}	1262
metaborate	$B_3O_6^{3-}$	26
	K^+	380
sodium	Na^+	10 556
strontium	Sr^{2+}	13
	SO_4^{2-}	2649

(a) Answer these questions using only the information in the table.

(i) State which negative ion has the lowest mass in 1000 cm^3 of sea water.

..... [1]

(ii) Give the formulae of the ions in potassium sulfate.

..... and ..... [1]

(iii) Calculate the mass of calcium ions in 200 cm^3 of this sample of sea water.

mass = ... mg [1]

(iv) A sample of this sea water is evaporated.

State the name of the compound which is present in the greatest quantity when this sample is evaporated.

..... [1]

(v) Give the name of the ion which reacts with aqueous silver nitrate to give a cream precipitate.

..... [1]

(b) The $B_3O_6^{3-}$ ion can be converted to boric acid, H_3BO_3.

Boric acid is also produced when boron trichloride, BCl_3, reacts with water.

Complete the equation for this reaction.

$$BCl_3 + ...H_2O \rightarrow H_3BO_3 + ...HCl$$ [2]

(c) The symbol of a strontium ion is shown.

$$^{87}_{38}Sr^{2+}$$

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

number of electrons .....

number of protons .....

number of neutrons .....

[3]

(d) Some isotopes of strontium are radioactive.

(i) Give **one** medical use of radioactive isotopes.

..... [1]

(ii) The isotope ^{235}U is also radioactive.

State the major use of this isotope of uranium.

..... [1]

[Total: 12]

42. March/2021/Paper_42/No.1

The table shows the numbers of protons, neutrons and electrons in particles **A** to **I**.

particle	protons	neutrons	electrons
A	1	0	0
B	6	6	6
C	6	8	6
D	10	10	10
E	16	16	18
F	17	18	17
G	18	22	18
H	19	20	19
I	20	20	18

Answer the following questions about particles **A** to **I**. Each letter may be used once, more than once or not at all.

(a) State which of the particles **A** to **I**:

(i) is an anion ..... [1]

(ii) are cations ..... and ..... [2]

(iii) are noble gas atoms ..... and ..... [2]

(iv) is a halogen atom ..... [1]

(v) is a Group I atom ..... [1]

(vi) have the same nucleon number ..... and ..... [1]

(vii) causes acidity in aqueous solutions ..... [1]

(viii) is used to define the relative atomic mass of elements. ..... [1]

(b) Explain why **B** and **C** are isotopes of the same element.

.....

..... [2]

[Total: 12]