1)

A particle with a **single** positive charge and with the electronic configuration $1s^2\ 2s^2\ 2p^6$ is

☒ **A** a sodium ion.

☒ **B** a fluoride ion.

☒ **C** an oxide ion.

☒ **D** a potassium ion.

2)

In which of the following electronic configurations are only two of the electrons unpaired?

☒ **A** $1s^2\ 2s^2$

☒ **B** $1s^2\ 2s^2\ 2p^3$

☒ **C** $1s^2\ 2s^2\ 2p^4$

☒ **D** $1s^2\ 2s^2\ 2p^5$

3)

Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

4)

Which of the following ions has the **largest** ionic radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

5)

Which of the following observations provides the best evidence for the presence of ionic bonding in an unknown substance?

The substance conducts electricity

☒ **A** in the solid state.

☒ **B** in the solid state and in aqueous solution.

☒ **C** in the solid state and when molten.

☒ **D** when molten but not in the solid state.

6)

1.12 g of iron reacts with oxygen to form 1.60 g of an oxide of iron.
Use relative atomic masses: Fe = 56, O = 16.

What is the formula of this oxide of iron?

- ☐ **A** FeO_5
- ☐ **B** Fe_2O_{10}
- ☐ **C** Fe_3O_2
- ☐ **D** Fe_2O_3

7)

In an experiment, 1.226 g of potassium chlorate(V), $KClO_3$, was heated. A mass of 0.320 g of oxygen gas, O_2, was collected.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

Use the molar mass of $KClO_3$ = 122.6 g mol^{-1} and relative atomic mass O = 16.

The percentage yield of oxygen in this experiment is

- ☐ **A** 17.4%
- ☐ **B** 26.1%
- ☐ **C** 66.7%
- ☐ **D** 100%

8)

Oxygen gas, O_2, can be converted into ozone, O_3, by passing it through an electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

In an experiment, a volume of 300 cm^3 of oxygen was used but only 10% of the oxygen was converted into ozone. All volumes were measured at the same temperature and pressure.

The **total** volume of gas present at the end of the experiment, in cm^3, was

- ☐ **A** 200
- ☐ **B** 210
- ☐ **C** 290
- ☐ **D** 300

9)

Consider the following Group 2 compounds.

Group 2 hydroxides	Group 2 sulfates
$Mg(OH)_2$	$MgSO_4$
$Ca(OH)_2$	$CaSO_4$
$Sr(OH)_2$	$SrSO_4$

The solubility

☐ **A** increases down the group for both hydroxides and sulfates.

☐ **B** increases down the group for hydroxides but increases up the group for sulfates.

☐ **C** increases up the group for hydroxides but increases down the group for sulfates.

☐ **D** increases up the group for both hydroxides and sulfates.

10)

Which of the following is the correct equation for the decomposition of the corresponding nitrate?

☐ **A** $4LiNO_3 \rightarrow 2Li_2O + 4NO_2 + O_2$

☐ **B** $4NaNO_3 \rightarrow 2Na_2O + 4NO_2 + O_2$

☐ **C** $Mg(NO_3)_2 \rightarrow Mg(NO_2)_2 + O_2$

☐ **D** $Ba(NO_3)_2 \rightarrow Ba(NO_2)_2 + O_2$

11)

What is the oxidation number of phosphorus in P_4O_6?

☐ **A** +3

☐ **B** +4

☐ **C** +5

☐ **D** +6

12)

For barium, the third ionization energy is higher than the second ionization energy because

☐ **A** there is an increase in the number of protons.

☐ **B** there is an increase in the shielding.

☐ **C** the ionic radius is greater.

☐ **D** the electron being removed is closer to the nucleus.

13)
When steam is passed over heated magnesium, which of the following occurs?

☒ **A** $Mg + H_2O \rightarrow MgO + H_2$

☒ **B** $Mg + H_2O \rightarrow MgOH + \frac{1}{2}H_2$

☒ **C** $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$

☒ **D** There is no reaction with the magnesium.

14)
Which of the following will **not** affect the rate of the reaction below?

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

☒ **A** Surface area

☒ **B** Concentration

☒ **C** Pressure

☒ **D** Temperature

15)
Brand **X** is unlike many conventional toilet cleaners in that it does not contain bleach, but instead contains hydrochloric acid. The label states that the toilet cleaner contains 9 g of HCl per 100 cm³ of the toilet cleaner.

An industrial technician was given the task of checking the validity of this statement. Using 25.0 cm³ portions of the toilet cleaner, the technician carried out a titration using 2.50 mol dm⁻³ sodium hydroxide solution and obtained the following results.

Titration	Trial	1	2
Final Volume /cm³	25.00	49.60	24.50
Initial Volume /cm³	0.00	25.00	0.00
Volume Added /cm³			

(a) (i) Complete the table and calculate the mean titre by selecting the appropriate results.
(1)

(ii) Write the equation for the titration reaction. State symbols are not required.
(1)

(iii) Calculate the number of moles of sodium hydroxide that reacted.
(1)

(iv) Hence state the number of moles of hydrochloric acid that reacted with the sodium hydroxide.

(1)

(v) Calculate the mass of HCl present in 100 cm^3 of the toilet cleaner. Give your answer to 3 significant figures.

(2)

(vi) Using the technician's results, comment on the validity of the manufacturer's statement that the toilet cleaner contained 9 g of HCl per 100 cm^3. Justify your answer.

(1)

(vii) Explain why titrations involving the use of a 2.50 mol dm^{-3} sodium hydroxide solution would **not** be advisable in a school or college laboratory.

(1)

(b) Conventional toilet cleaners contain a bleaching agent. Chloric(I) acid, HOCl, is one such substance.

Draw the dot and cross diagram for chloric(I) acid. Show outer electrons only.

(1)

(c) The instructions for the use of Brand **X** state that the toilet cleaner should not be used with bleaching agents.

Complete the equation for the reaction between the hydrochloric acid in the toilet cleaner and the chloric(I) acid in the bleaching agent. Give a reason why this reaction is to be avoided in accordance with the instructions for the use of the toilet cleaner.

(2)

Equation HCl + HOCl →

Reason ....

(d) Another bleaching agent is sodium chlorate(I), NaClO, which can be purchased as a solution. It can also be obtained by bubbling chlorine gas into sodium hydroxide solution.

(i) Give the oxidation numbers of the chlorine-containing species in the equation below and classify the reaction as a result of your answer.

$$2NaOH(aq) + Cl_2(g) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$$

Oxidation Number ....

(2)

Type of reaction ....

(ii) State how the reaction conditions would need to be changed in order to produce sodium chlorate(V) instead of sodium chlorate(I).

(1)

(iii) Give the equation for the reaction between chlorine and sodium hydroxide solution that forms sodium chlorate(V) as one of the products. State symbols are not required.

(2)

16)

Spontaneous combustion is often a subject of fantasy in movies, but it does actually happen with some chemical compounds. One such compound is silane, SiH_4, which is analogous to methane, CH_4. Methane is the main gas that is used in school and college laboratories with Bunsen burners, but it requires a spark or a lighted splint to ignite. Silane does not require any such ignition, and at room temperature is spontaneously flammable. This can make an interesting chemical demonstration.

One method of making silane is by mixing together two solids, silicon dioxide and magnesium, with the magnesium being in excess. The two chemicals are thoroughly mixed together. This mixture is then heated to red-heat and initially produces powdered silicon. The silicon then reacts further with the excess magnesium powder and forms magnesium silicide, Mg_2Si. The two reactions which occur are shown in the equations below.

$$SiO_2 + 2Mg \longrightarrow 2MgO + Si$$

$$Si + 2Mg \longrightarrow Mg_2Si$$

The magnesium silicide formed is then reacted with hydrochloric acid to form silane, SiH_4.

(a) Complete and balance the equation for this reaction. State symbols are not required.

(2)

Mg_2Si + ...HCl $\longrightarrow$ .... + ...

(b) Bubbles of silane rise to the surface in the reaction mixture and spontaneously combust with oxygen in the air.

Suggest the names or formulae of the products of the reaction between silane and oxygen.

(2)

(c) Predict the molecular shape of silane, SiH_4, and suggest the bond angle.

(2)

Shape ....

Bond angle ....

(d) Explain why the Si—H bond is longer than the C—H bond.

(2)

*(e) Identify the intermolecular forces present in pure samples of both silane and methane.

Explain why silane has a higher boiling temperature than methane and why both are gases at room temperature.

(4)

(f) (i) Define the term **electronegativity**.

(2)

*(ii) Some Pauling electronegativity values for selected elements are given below.

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0

Using the values in the table above, compare the polarity of the bonds in a molecule of methane with that found in a molecule of silane.

Comment on the significance of any difference.

(3)

(iii) Using the table in (f)(ii), choose an element which, when covalently bonded to hydrogen, forms a molecule containing bonds that are more polar than those in silane or methane. Give the formula of the hydride of your chosen element and state the electronegativity difference.

(2)

(iv) Explain why it is possible for the bonds within a molecule to be polar, but for the molecule itself to be non-polar. Give an example of such a molecule.

(2)

17)

Lattice energies can be calculated from experimental data using Born-Haber cycles.

In the table below are the enthalpy changes needed to calculate the lattice energy of sodium oxide, Na_2O.

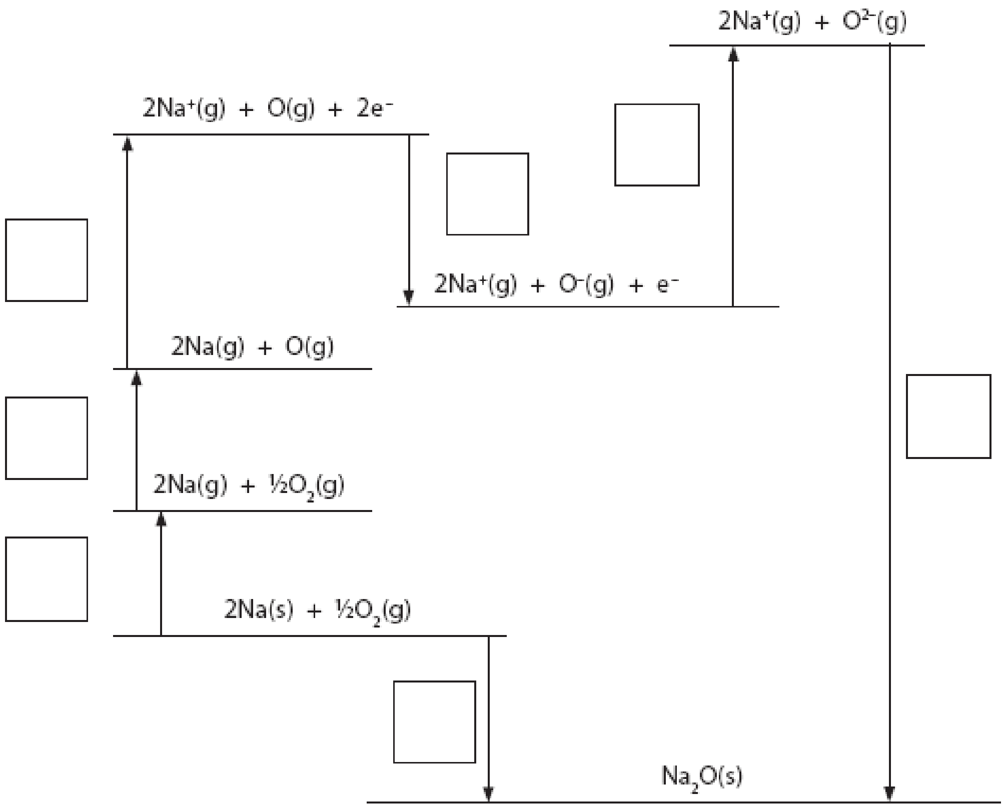
Letter	Enthalpy change	Value / kJ mol^{-1}
A	1st electron affinity of oxygen	−141
B	2nd electron affinity of oxygen	+790
C	1st ionization energy of sodium	+496
D	enthalpy change of atomization of sodium	+108
E	enthalpy change of atomization of oxygen, ½O_2(g)	+249
F	enthalpy change of formation of sodium oxide	−414
G	lattice energy of sodium oxide	

(a) Define the term **lattice energy**.

(2)

(b) (i) Write the correct letters from the table of data to label the Born-Haber cycle below.

(3)



(ii) Calculate the lattice energy of sodium oxide, enthalpy change **G**, in kJ mol^{-1}.

(2)

*(c) Predict whether the lattice energy of magnesium oxide, MgO, is more or less exothermic than the lattice energy of magnesium sulfide, MgS.

Justify your answer in terms of the sizes and the charges of the ions involved.

(4)

17)

Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

$1s^2$ ....

(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
^{58}Ni	69.02
^{60}Ni	27.32
^{62}Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, $Ni(CO)_4$.

$$Ni(s) + 4CO(g) \rightarrow Ni(CO)_4(g)$$

(i) Calculate the volume of carbon monoxide, in dm^3, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7
Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(1)

(d) Nickel(II) nitrate, $Ni(NO_3)_2$, can be made by several different methods.

Method 1
Nickel(II) oxide, NiO, was reacted with dilute nitric acid according to the equation

$$NiO(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l)$$

(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3, that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: Ni = 58.7, O = 16.0

(3)

Method 2
A volume of 25.0 cm^3 of 2.00 mol dm^{-3} nitric acid, HNO_3, was transferred to a beaker. Solid nickel(II) carbonate, $NiCO_3$, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

(2)

*(v) For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)