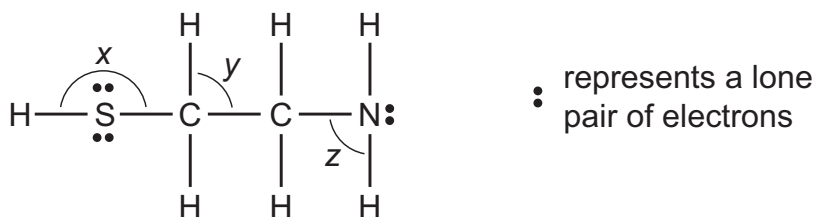


- 5 Which statement explains why sodium and potassium have different melting points?
- A** The attraction between cations and delocalised electrons is stronger in sodium.
- B** The attraction between cations and anions is stronger in sodium.
- C** The attraction between atoms is stronger in sodium.
- D** The attraction between nuclei and shared electron pairs is stronger in sodium.

- 6 Three bond angles are labelled on the molecule shown.



What is the order of **decreasing** size of the bond angles x , y and z ?

	largest	→	smallest
A	x	y	z
B	x	z	y
C	y	z	x
D	z	y	x

- 6 NH_3 and HCN react together to form NH_4CN , an ionic compound.

Which row states the number of coordinate bonds and the number of π bonds in one formula unit of NH_4CN ?

	number of coordinate bonds	number of π bonds
A	0	2
B	1	2
C	0	3
D	1	3

- 24** When dry ammonia and hydrogen chloride gases are mixed, a solid white ionic compound is formed.

Two statements are listed.

- 1 The formation of the ionic compound is a redox reaction.
- 2 During the formation of the ionic compound, the H–N–H bond angle increases.

Which statements are correct?

- A** both 1 and 2
B 1 only
C 2 only
D neither 1 nor 2

- 7** The boiling point of water, H_2O , is higher than that of hydrogen sulfide, H_2S .

Which statement explains this difference in boiling points?

- A** The bond energy of O–H is greater than the bond energy of S–H.
B The intermolecular forces in H_2O are weaker than the intermolecular forces in H_2S .
C The S–H bond in H_2S is longer than the O–H bond in H_2O .
D There is significant intermolecular hydrogen bonding in H_2O but **not** in H_2S .

1 Chromium, Cr, and its compounds are widely used in many chemical reactions.

(a) Cr exists as four stable isotopes.

(i) The most common isotope of Cr is chromium-52.

Determine the number of protons, neutrons and electrons in an atom of chromium-52.

number of protons neutrons electrons [1]

(ii) Describe how an atom of chromium-54 differs from an atom of chromium-52. Refer to numbers of particles in your answer.

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

(iii) The relative isotopic masses of the isotopes of Cr can be determined using mass spectrometry.

State what other information is needed to calculate the relative atomic mass, A_r , of Cr.

..... [1]

(iv) Atoms of ^{52}Cr , ^{53}Cr and ^{54}Cr make up more than 95% of naturally occurring chromium atoms. The A_r of naturally occurring Cr is 51.996.

Suggest what these statements imply about the relative isotopic mass of the fourth stable isotope of chromium.

..... [1]

(b) The shorthand electronic configuration of chromium is $[\text{Ar}] 3d^5 4s^1$.

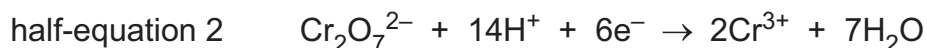
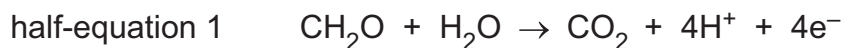
(i) Complete the full electronic configuration of chromium.

..... $3d^5 4s^1$ [1]

(ii) Deduce the total number of unpaired electrons in an atom of chromium.

..... [1]

- (c) Acidified dichromate(VI) ions will convert methanal, CH_2O , to carbon dioxide. The movement of electrons to or from relevant species is shown in the following half-equations.



- (i) Identify the species that is reduced in half-equation 2. Explain your answer.

..... [1]

- (ii) The oxidation state of the carbon atom in methanal is 0.

Calculate the oxidation state of carbon in carbon dioxide.

..... [1]

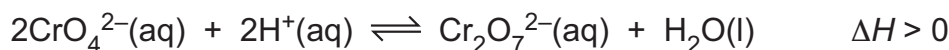
- (iii) Construct the ionic equation for the reaction of dichromate(VI) ions with methanal in acidic conditions.

..... [2]

- (iv) Methanal is a liquid at -30°C but carbon dioxide is a gas at this temperature. Explain why.

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

- (d) In acidic conditions, a dynamic equilibrium is established between $\text{CrO}_4^{2-}(\text{aq})$ and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$.



- (i) State what is meant by dynamic equilibrium.

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

- (ii) Identify the condition necessary to establish dynamic equilibrium.

..... [1]

- (iii) $\text{CrO}_4^{2-}(\text{aq})$ ions are yellow and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ ions are orange.

State what is observed when the following changes are made to an equilibrium mixture of acidified $\text{CrO}_4^{2-}(\text{aq})$ and $\text{Cr}_2\text{O}_7^{2-}(\text{aq})$ ions.

Explain your answers.

- The equilibrium mixture is warmed gently.

observation

explanation

.....

.....

- Dilute $\text{HCl}(\text{aq})$ is added to the equilibrium mixture.

observation

explanation

.....

.....

[4]

- (e) Chromium(IV) fluoride, CrF_4 , is a covalent molecule that shows similar chemical properties to SiCl_4 .

Suggest the type of reaction that occurs when CrF_4 is placed in water.

Construct a relevant equation for this reaction.

type of reaction

equation

[2]

1 The Group 17 elements are oxidising agents.

(a) (i) Explain how the Group 17 elements act as oxidising agents.

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

(ii) Write an equation to show the reaction in which Cl_2 oxidises aluminium metal.

..... [1]

(iii) A student heats equal amounts of $\text{I}_2(\text{g})$ and $\text{H}_2(\text{g})$ in a sealed flask. The student leaves the contents to cool.

State what you would observe during the reaction.

..... [1]

(b) Cl_2 and Br_2 can each react with NH_3 to give N_2 and a hydrogen halide, HX .



The relative bond strengths of X-X and H-X determine the difference in enthalpy change of the two reactions.

(i) Describe and explain the difference in the X-X bond strengths of Cl_2 and Br_2 .

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

(ii) Describe the relative thermal stabilities of HCl and HBr .

..... [1]

(iii) Define enthalpy change of formation, ΔH_f .

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

(iv) Table 1.1 gives data relevant to the reaction of $Cl_2(g)$ with $NH_3(g)$.

Table 1.1

compound	enthalpy change of formation, $\Delta H_f / \text{kJ mol}^{-1}$
$NH_3(g)$	−46
$HCl(g)$	−92

Use the data in Table 1.1 to calculate the enthalpy change of the reaction of $Cl_2(g)$ with $NH_3(g)$.

enthalpy change of reaction = kJ mol^{-1} [2]

(v) I_2 reacts with NH_3 to form NI_3 .

Predict the shape of a molecule of NI_3 . Explain your answer.

shape

explanation

..... [2]

(c) Table 1.2 shows some information about reactions of NaCl , NaBr and NaI .

Table 1.2

	NaCl	NaBr	NaI
observation with $\text{Ag}^+(\text{aq})$	white precipitate		
type of reaction with concentrated H_2SO_4	acid–base	acid–base, then redox	acid–base, then redox
observations with concentrated H_2SO_4			• black solid • yellow solid • effervescence

(i) Complete Table 1.2. [4]

(ii) Suggest an identity for the species that produces each observation in the reaction of NaI with concentrated H_2SO_4 .

black solid

yellow solid

effervescence

[2]

(d) Table 1.3 gives some information about MgCl_2 and SiCl_4 .

Table 1.3

	MgCl_2	SiCl_4
electrical conductivity when liquid	conducts	does not conduct
observation when added to water	dissolves	vigorous reaction

(i) Explain the difference between the electrical conductivity of liquid MgCl_2 and of liquid SiCl_4 . Refer to bonding and relevant particles in your answer.

.....

.....

.....

.....

..... [2]

(ii) Suggest the pH of the solutions that form when each chloride is added to water.

MgCl_2 SiCl_4

[2]