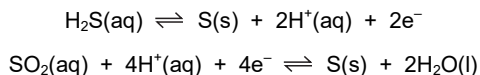


- 3 The reaction of hydrogen sulfide with sulfur dioxide gives sulfur as one of the products.

The two relevant redox equations are shown.



How many moles of hydrogen sulfide are needed to react with sulfur dioxide to produce 1 mol of sulfur?

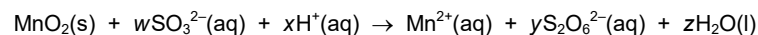
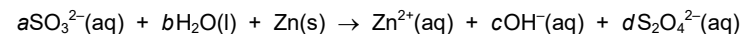
- A $\frac{1}{3}$ mol B $\frac{2}{3}$ mol C $\frac{3}{2}$ mol D 2 mol

- 11 In which substance is the average oxidation number of sulfur the highest?

- A S_8 B $\text{Na}_2\text{S}_4\text{O}_6$ C $\text{Na}_2\text{S}_2\text{O}_3$ D SO_2Cl_2

- 9 Sulfite ions, SO_3^{2-} , react separately with zinc and with manganese dioxide.

a , b , c , d , w , x , y and z are all whole numbers.



Which numbers are correct for a , b , w and x ?

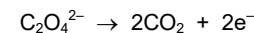
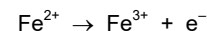
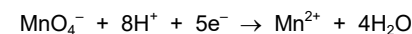
	a	b	w	x
A	1	2	2	4
B	2	2	2	4
C	1	2	4	2
D	2	2	4	2

- 10 Which equation shows hydrogen acting as an oxidising agent?

- A $\text{H}_2 + 2\text{K} \rightarrow 2\text{K}^+\text{H}^-$
 B $\text{H}_2 + \text{I}_2 \rightarrow 2\text{HI}$
 C $\text{H}_2 + \text{Cu}_2\text{S} + \text{ZnO} \rightarrow 2\text{Cu} + \text{ZnS} + \text{H}_2\text{O}$
 D $3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3$

- 11 Acidified potassium manganate(VII) reacts with iron(II) ethanedioate, FeC_2O_4 .

The reactions taking place are shown.



How many moles of iron(II) ethanedioate react with **one** mole of potassium manganate(VII)?

- A 0.60 B 1.67 C 2.50 D 5.00

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 $[\text{Ar}] 3d^5 4s^1$.

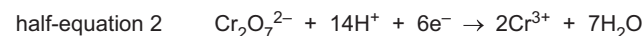
(i) Complete the full electronic configuration of chromium.

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

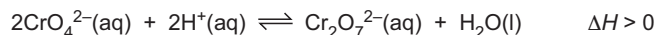
(iii) Construct the ionic equation for the reaction of dichromate(VI) ions with methanal in acidic conditions.

..... [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]

- 4 (a) Define standard cell potential, $E_{\text{cell}}^\ominus$. Include a description of standard conditions.

.....

 [2]

- (b) The Daniell cell is an electrochemical cell consisting of a $\text{Cu}^{2+}(\text{aq})/\text{Cu}(\text{s})$ electrode and a $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$ electrode.

- (i) Draw a labelled diagram of this electrochemical cell.

Include all necessary substances and relevant pieces of apparatus needed to measure the $E_{\text{cell}}^\ominus$.

It is **not** necessary to state the conditions used.

- (ii) State the charge carriers that transfer current through the solutions and through the wire.

the solutions the wire [1]

- (iii) The standard electrode potential, $E^\ominus$, for the $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$ electrode is -0.76 V .

Water is added to a standard $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$ electrode.

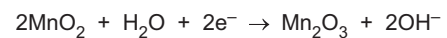
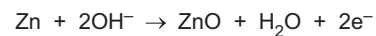
The new concentration of $\text{Zn}^{2+}(\text{aq})$ is 0.25 mol dm^{-3} .

Use the Nernst equation to calculate the electrode potential, E , for this new $\text{Zn}^{2+}(\text{aq})/\text{Zn}(\text{s})$ electrode.

- (c) An electrochemical cell consists of a ZnO/Zn electrode and a $\text{MnO}_2/\text{Mn}_2\text{O}_3$ electrode in an alkaline electrolyte.

The standard cell potential, E°_{cell} , for this cell is +1.47 V.

The half-equation at each electrode when this cell is discharging is shown.



- (i) Use this information to determine the change in oxidation state of manganese when this cell is discharging.

from to [1]

- (ii) Write the equation for the overall reaction that occurs when this cell is discharging.

..... [1]

- (iii) The E° for the ZnO/Zn electrode is -1.28 V .

Calculate the standard electrode potential, E° , for the $\text{MnO}_2/\text{Mn}_2\text{O}_3$ electrode.

$E^\circ (\text{MnO}_2/\text{Mn}_2\text{O}_3) = \dots\dots\dots \text{ V}$ [1]

[Total: 11]