Electrochemistry – 2021 AS

1. Nov/2021/Paper_12/No.32

Four solutions, each of concentration 0.1 mol dm^{-3}, were tested with a pH meter. The results are shown.

solution	formula of acid or base	pH
acid 1	CH_3CO_2H	4
acid 2	HNO_3	1
base 1	CH_3NH_2	11
base 2	NaOH	14

Which statements explain these results?

1 Acid 2 has a lower pH than acid 1 because it is more soluble.

2 Base 2 has a higher concentration of hydroxide ions in solution than base 1.

3 Acid 1 dissociates less than acid 2.

C

2. Nov/2021/Paper_21/No.1(c)

(c) Hydrogen sulfide gas, $H_2S(g)$, is slightly soluble in water. It acts as a weak acid in aqueous solution.

(i) State the meaning of *weak acid*.

Its an acid that partially dissociates into H^+.

[1]

(ii) Give the formula of the conjugate base of H_2S.

HS^-

[1]

(iii) $H_2S(aq)$ reacts slowly with oxygen dissolved in water. The reaction is represented by the following equation.

$$H_2S(aq) + \tfrac{1}{2}O_2(aq) \rightarrow H_2O(l) + S(s)$$

$-2 \quad 0 \quad -2 \quad 0$

Explain, with reference to oxidation numbers, why this reaction is a redox reaction.

Sulfur has its oxidation number increasing from -2 to 0, while the oxidation number of oxygen decreases from 0 to -2.

[2]

Acid Base

$H_2S + H_2O \longrightarrow H_3O + HS^-$

C. Acid C. Base.

3. Nov/2021/Paper_21/No.3

Phosphorus is a reactive Period 3 element.

(a) Phosphorus has several allotropes. Details of two allotropes are given.

allotrope of phosphorus	formula	melting point / °C
white	P_4	44
red	P	590

(i) White phosphorus and red phosphorus both have covalent bonding.

Suggest the types of structure shown by white phosphorus (P_4) and red phosphorus (P).

Explain why red phosphorus (P) has a higher melting point than white phosphorus (P_4).

structure of P_4 Simple molecular.

structure of P Giant molecular.

explanation P has strong covalent bonds that require alot of energy to overcome it while P_4 has weak intermolecular forces of attraction.

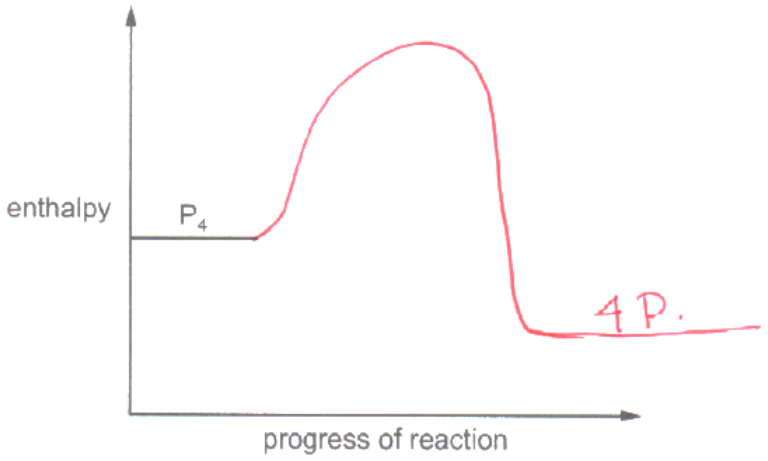
[3]

(ii) Red phosphorus (P) forms when white phosphorus (P_4) is exposed to sunlight.

$$\tfrac{1}{4}P_4(s) \rightarrow P(s) \qquad \Delta H = -17.6\ kJ\ mol^{-1}$$

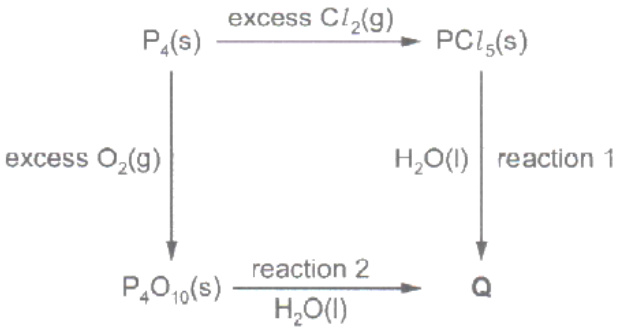
white red

Use this information to draw a reaction pathway diagram to show the formation of red phosphorus (P) from white phosphorus (P_4).



[1]

(b) Some reactions of $P_4(s)$ are shown in the reaction scheme.



4P + 10(-2) = 0
4P = +20
4 4
P = +5

(i) State the oxidation number of phosphorus in P_4O_{10}.

+5 ..... [1]

(ii) Deduce the identity of **Q** and hence construct chemical equations for reactions 1 and 2.

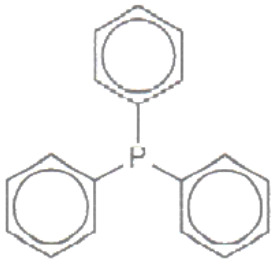
reaction 1 PCl_5 + 4 H_2O → H_3PO_4 + 5HCl

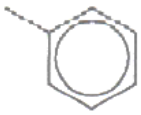
reaction 2 P_4O_{10} + 6 H_2O → 4 H_3PO_4

[2]

(c) Triphenylphosphine is used in a type of reaction known as a *Wittig reaction*.

triphenylphosphine



where  = $-C_6H_5$

(i) Give the empirical formula of triphenylphosphine.

$C_{18}H_{15}P$. ..... [1]

(also its molecular formular)

In a Wittig reaction, an aldehyde reacts with a halogenoalkane to form an alkene. The conversion is shown in the following unbalanced equation.

Compound **H** can be made from propanal, C_2H_5CHO. Stage 3 in the reaction scheme is a Wittig reaction.

stage 1 $C_2H_5CHO \xrightarrow{NaBH_4} \mathbf{G}$

stage 2 $\mathbf{G} \xrightarrow{\text{red phosphorus and } I_2} C_2H_5CH_2I$

stage 3 (Wittig reaction) $C_2H_5CH_2I + C_2H_5CHO \xrightarrow[\text{strong base}]{\text{triphenylphosphine}} \mathbf{H}$

(ii) State the types of reaction that occur in stages 1 and 2.

stage 1 Reduction.

stage 2 Substitution.

[2]

(iii) Draw the structures of **G** and **H** in the boxes provided.

G

$C_2H_5CH_2OH$

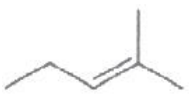
H

$C_2H_5CH=CHC_2H_5$

[2]

(d) Identify the organic products formed when compound **J**, shown below, is heated with hot concentrated acidified manganate(VII) ions.

J



hot concentrated MnO_4^- / H_2SO_4

CH_3CH_2COOH + CH_3COCH_3.

[2]

[Total: 14]

4. March/2021/Paper_12/No.8

VO_2Cl reacts with NaI under acidic conditions.

$$2VO_2Cl + 2H_2SO_4 + 2NaI \rightarrow VOCl_2 + VOSO_4 + I_2 + Na_2SO_4 + 2H_2O$$

(−1 under VO_2Cl; −1 under $VOCl_2$)

The oxidation state of Cl is –1 in VO_2Cl and in $VOCl_2$.

Which row about this reaction is correct?

	vanadium	iodine
A	is oxidised	is oxidised
B	is oxidised	is reduced
C	is reduced	is oxidised
D	is reduced	is reduced

Iodine is reduced in NaI, I^- has an oxidation number of −1 while in I_2 its oxidation number is 0 (zero)

VO_2Cl: $V + (-2)2 + -1 = 0$; $V = +5$

$VOCl_2$: $V + (-2) + (-1)2 = 0$; $V = +4$ oxidation

$VOSO_4$: $V + -2 + -2 = 0$; $V = +4$ decreases - It is reduced.

5. June/2021/Paper_11/No.9

When hydrogen iodide is reacted with concentrated sulfuric acid, several reactions occur, including:

$$8HI + H_2SO_4 \rightarrow H_2S + 4H_2O + 4I_2$$

$8H^+ + 8I^- + 2H^+ + SO_4^{2-} \rightarrow 2H^+ + S + 4H_2O + 4I_2$.

Which row gives the change in oxidation number of iodine and of sulfur in this reaction?

	change in oxidation number of iodine	change in oxidation number of sulfur
A	–1	+6
B	–1	+8
C	+1	–6
D	+1	–8

HI

$I^- \rightarrow I_2$

$-1 \rightarrow 0$

on the positive direction (+1)

H_2S

$2(+1) + S = 0$

$S = -2$

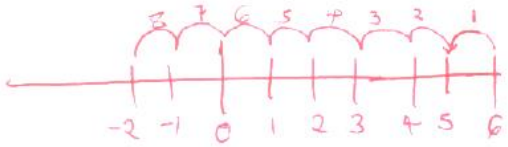
H_2SO_4

$2(+1) + S + 4(-2) = 0$

$S = -2 + 8$

$= +6$

$+6 \rightarrow -2$



on the negative direction (-8)

6. June/2021/Paper_11/No.25

When an organic compound is oxidised, any oxygen atom gained by the organic molecule is considered to be from a water molecule also producing $2H^+ + 2e^-$. Any hydrogen atom lost may be considered to be lost as $H^+ + e^-$.

These changes can be represented by the following two equations.

$$H_2O \rightarrow [O] + 2H^+ + 2e^-$$

$$[H] \rightarrow H^+ + e^-$$

Compound X is oxidised by heating under reflux with hot, acidified potassium dichromate(VI) for one hour. The half-equation for the reduction reaction is shown.

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

Under these conditions, one mole of potassium dichromate(VI) oxidises three moles of X.

What could X be?

A propanal

B propan-1-ol

C propan-1,2-diol

D propan-1,3-diol

7. June/2021/Paper_12/No.9

The equation for a redox reaction is shown.

$$SnCl_2(aq) + 2HgCl_2(aq) \rightarrow SnCl_4(aq) + Hg_2Cl_2(s)$$

Which species is being oxidised in this reaction?

A Sn^{2+} B Cl^- C Hg^+ D Hg^{2+}

8. June/2021/Paper_13/No.32

The equation shows the decomposition of three moles of an ion containing chromium in an acid solution.

$3CrO_4^{3-}(aq) + 8H^+(aq) \rightarrow 2CrO_4^{2-}(aq) + Cr^{3+}(aq) + 4H_2O(l)$

B

Which statements are correct?

1 One mole of CrO_4^{3-} is reduced. ✓

2 Two moles of CrO_4^{3-} are oxidised. ✓

3 Three moles of electrons are transferred. ✗

9. June/2021/Paper_13/No.35

Which reagents produce a solution of sodium chlorate(V)?

D

1 chlorine and hot concentrated sodium hydroxide solution ✓

2 chlorine and cold dilute sodium hydroxide solution – chlorate(I)

3 chlorine dissolved in water at room temperature – HOCl.

10. June/2021/Paper_23/No.1 (f)

Sodium chlorate(I), NaC*l*O, oxidises dilute hydrochloric acid to form three products. The products which contain chlorine have chlorine species with oxidation number –1 or 0.

No other species changes its oxidation number during the reaction.

Use this information to complete the ionic equation.

.....ClO^- + ..2..HCl → ..Cl^-.. + ..Cl_2.. + ..H_2O.. [2]

[Total: 13]