

Thermodynamics

1. The correct order of bond dissociation enthalpy of halogens is

- ☒ A. $Cl_2 > Br_2 > F_2 > I_2$
- ☐ B. $F_2 > Cl_2 > Br_2 > I_2$
- ☐ C. $Cl_2 > F_2 > Br_2 > I_2$
- ☐ D. $I_2 > Br_2 > Cl_2 > F_2$

Answer (1)

Bond dissociation energy of halogen family decreases down the group as the size of atom increases. But F_2 has $F-F$, F_2 involves repulsion of non-bonding electrons and more over its size is small. So, due to repulsions its bond becomes weak and hence bond dissociation energy is very low.

Thermodynamics

2. During which of the following processes, does entropy decrease?

- (A) Freezing of water to ice at 0°C
- (B) Freezing of water to ice at -10°C
- (C) $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$
- (D) Adsorption of $\text{CO}(\text{g})$ on lead surface
- (E) Dissolution of NaCl in water

Choose the correct answer from the options given below.

- ☒ A. (A) and (E) only
- ☒ B. (A), (C) and (E) only
- ☒ C. (A), (B), (C) and (D) only
- ☒ D. (B) and (C) only

A, B \rightarrow Freezing of water will decrease entropy as particles will move closer and forces of attraction will increase. This leads to a decrease in randomness. So, entropy decreases.

C \rightarrow No. of molecules decreasing on product side so entropy decreases.

D \rightarrow Adsorption will lead to a decrease in the randomness of gaseous particles. So, entropy decreases.

E $\rightarrow \text{NaCl}(\text{s}) \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq}); \Delta S > 0$

Hence, for (A, B, C, D) entropy will decrease.

3. The statement that is incorrect about Ellingham diagram is:

- ☒ A. provides idea about the reaction rate.
- ☒ B. provides idea about free energy change.
- ☒ C. provides idea about changes in the phases during the reaction
- ☒ D. provides idea about reduction of metal oxide

Ellingham diagram provide ideas about free energy change, phase change during the reaction and reduction of metal oxide but does not provide idea about reaction rate.

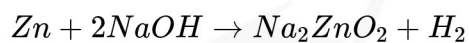
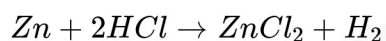
Thermodynamics

4. Which one of the following statements is incorrect?

- ☒ A. Bond dissociation enthalpy of H_2 is highest among diatomic gaseous molecules which contain a single bond
- ☒ B. Atomic hydrogen is produced when H_2 molecules at a high temperature are irradiated with UV radiation
- ☒ C. At around 2000 K, the dissociation of dihydrogen into its atoms is nearly 8.1%
- ☒ D. Dihydrogen is produced on reacting zinc with HCl as well as $NaOH$ (aq)

The $H - H$ bond dissociation enthalpy is the highest for a single bond between two atoms of any element.

It is because of this factor that the dissociation of dihydrogen into its atoms is only $\sim 0.081\%$ around 2000 K. The atomic hydrogen is produced at a high temperature in an electric arc or under ultraviolet radiations.



Thermodynamics

5. The incorrect expression among the following is:

- ☒ A. For isothermal process $w_{reversible} = -nRT \ln \frac{V_f}{V_i}$
- ☒ B. $\frac{\Delta G_{system}}{\Delta S_{Total}} = -T_{(at\ constant\ P)}$
- ☒ C. $\ln K = \frac{\Delta H^o - T\Delta S^o}{RT}$
- ☒ D. $K = e^{-\Delta G^o/RT}$

$$W_{rev} = -nRT \ln \left(\frac{V_f}{V_i} \right)$$

So, option (a) is the correct expression

$$\Delta G_{sys} = -T\Delta S_{Total}(at\ constant\ P)$$

So, option (b) is the correct expression

$$\Delta G^o = \Delta H^o - T\Delta S^o$$

$$-RT \ln K = \Delta H^o - T\Delta S^o$$

$$\ln K = \frac{\Delta H^o - T\Delta S^o}{-RT}$$

So, option (c) is the incorrect expression

$$\ln K = \frac{T\Delta S^o - \Delta H^o}{RT}$$

$$\Delta G^o = -RT \ln K$$

$$\frac{\Delta G^o}{-RT} = \ln K$$

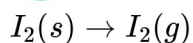
$$\Rightarrow K = e^{-\frac{\Delta G^o}{RT}}$$

So, option (d) is the correct expression

Thermodynamics

6. Enthalpy of sublimation of iodine is 24 cal g^{-1} at 200°C . If specific heat $I_2(s)$ and $I_2(vap)$ are 0.055 and $0.031 \text{ cal g}^{-1}\text{K}^{-1}$ respectively, then enthalpy of sublimation of iodine 250°C in cal g^{-1} is :

- ☐ A. 2.85
- ☐ B. 5.7
- ☒ C. 22.8
- ☐ D. 11.4



Heat of reaction depend upon temperature i.e., it varies with temperature, as given by Kirchoff's equation,

$$\Delta H_{T_2} = \Delta H_{T_1} + \int_{T_1}^{T_2} \Delta C_p dT$$

where $\Delta C_p = C_p$ of product $- C_p$ of reactant

$$\therefore \Delta C_p = 0.031 - 0.055 = -0.024 \text{ cal/g}$$

$$\text{Now, } \Delta H_{T_2} - \Delta H_{T_1} = \Delta C_p (T_2 - T_1)$$

$$\Delta H_{(250)} - \Delta H_{(200)} = -0.024(523 - 473)$$

$$\Delta H_{(250)} = 24 - 50 \times 0.024 = 22.8 \text{ cal/g}$$

Thermodynamics

7. For silver, $C_p(JK^{-1}mol^{-1}) = 23 + 0.01T$. If the temperature (T) of moles of silver is raised from 300 K to 1000K at 1 atm pressure, the value of ΔH will be close to:

- ☒ A. 62 kJ
☐ B. 16 kJ
☐ C. 21 kJ
☐ D. 13 kJ

Given: $n = 3$

$T_1 = 300; T_2 = 1000$

$C_p = 23 + 0.01T$

ΔH and C_p

$$\Delta H = \int_{T_1}^{T_2} nC_p dT$$

$$\Delta H = n \int_{300}^{1000} (23 + 0.01T) dT$$

$$= 3 \left[23(1000 - 300) + \frac{0.01}{2}(1000^2 - 300^2) \right]$$

$$= 3[16100 + 4550]$$

$$= 61.95kJ$$

$$= 3 \times 20650 = 61950J$$

$$\approx 62kJ$$

Thermodynamics

8. The enthalpy change on freezing of 1 mol of water at 5°C is ice at -5°C is :

(Given $\Delta_{fus}H = 6\text{kJ mol}^{-1}$ at 0°C ,

$$C_p(\text{H}_2\text{O}, l) = 75.3\text{J mol}^{-1}\text{K}^{-1}$$

$$C_p(\text{H}_2\text{O}, s) = 36.8\text{J mol}^{-1}\text{K}^{-1})$$

☐ A. 5.44kJ mol^{-1}

☐ B. 5.81kJ mol^{-1}

☒ C. 6.56kJ mol^{-1}

☐ D. 6.00kJ mol^{-1}

In order to calculate the enthalpy change for H_2O at 5°C , we need to calculate the enthalpy change of all the transformation involved in the process.

(a) Energy change of 1 mol, $\text{H}_2\text{O} (l)$ at $5^{\circ}\text{C} \rightarrow 1\text{ mol}\text{H}_2\text{O}(l), 0^{\circ}\text{C}$

(b) Energy change of 1 mol, $\text{H}_2\text{O} (l)$ at $0^{\circ}\text{C} \rightarrow 1\text{ mol}\text{H}_2\text{O}(s)(ice), 0^{\circ}\text{C}$

(c) Energy change of 1mol, ice (s), at $0^{\circ}\text{C} \rightarrow 1\text{ mol}, ice(s), -5^{\circ}\text{C}$

$$\text{Total } \Delta H = C_p[\text{H}_2\text{O}(l)]\Delta T + \Delta H_{freezing} + C_p[\text{H}_2\text{O}(s)]\Delta T$$

$$= (75.3\text{ J mol}^{-1}\text{K}^{-1})(0 - 5)\text{K} + (-6 \times 10^3\text{ J mol}^{-1}) + (36.8\text{J mol}^{-1}\text{K}^{-1})(-5 - 0)\text{K}$$

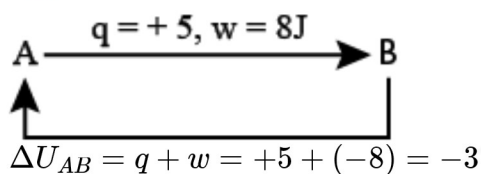
$$\Delta H = -6.56\text{ kJ mol}^{-1}$$

$$\Delta H = 6.56\text{ kJ mol}^{-1}$$

Thermodynamics

9. A gas undergoes change from state A to state B. In this process, the heat absorbed and work done by the gas is 5J and 8J, respectively. Now gas is brought back at A by another process during which 3J of heat is evolved. In this reverse process of B to A:

- ☒ A. 10 J of the work will be done by the gas.
- ☒ B. 6 J of the work will be done by the gas.
- ☒ C. 10 J of the work will be done by the surrounding on gas.
- ☒ D. 6 J of the work will be done by the surrounding on gas



$$q = -3, \Delta U_{BA} = +3$$

$$\Delta U_{BA} = q + w$$

$$\Rightarrow 3 = -3 + w$$

$$\Rightarrow w = +6$$

$$\Delta U_{BC} = -5kJ \text{ mol}^{-1}, q_{AB} = 2kJ \text{ mol}^{-1}$$

$$W_{AB} = -5kJ \text{ mol}^{-1}, W_{CA} = 3kJ \text{ mol}^{-1} \text{ (work done on the system).}$$

Thermodynamics

10. $q_{AB} = 2 \text{ kJ/mol}$
 $\Delta U_{BC} = -5 \text{ kJ/mol}$
 $W_{AB} = -5 \text{ kJ/mol}$
 $W_{CA} = 3 \text{ kJ/mol}$

Heat absorbed by the system during process CA is:

- ☐ A. -5 kJ mol^{-1}
- ☒ B. $+5 \text{ kJ mol}^{-1}$
- ☐ C. 18 kJ mol^{-1}
- ☐ D. -18 kJ mol^{-1}

$$\Delta U_{AB} = q_{AB} + W_{AB} = 2 + (-5) = -3 \text{ kJ/mol}$$

$$\Delta U_{BC} = -5 \text{ kJ/mol}$$

For cyclic process, $\Delta U = 0$

$$\Delta U_{AB} + \Delta U_{BC} + \Delta U_{CA} = 0$$

$$\Delta U_{CA} = -\Delta U_{AB} - \Delta U_{BC}$$

$$\Delta U_{CA} = -(-3) - (-5) = 8 \text{ kJ/mol}$$

$$\Delta U_{CA} = q_{CA} + W_{CA}$$

$$8 = q_{CA} + 3$$

$$q_{CA} = +5 \text{ kJ/mol}$$

Thermodynamics

11. At 298.2 K the relationship between enthalpy of bond dissociation (in kJ mol^{-1}) for hydrogen (E_H) and its isotope, deuterium (E_D), is best described by

☒ A. $E_H \simeq E_D - 7.5$

☐ B. $E_H = 2E_D$

☐ C. $E_H = \frac{1}{2}E_D$

☐ D. $E_H = E_D$

Enthalpy of bond dissociation of hydrogen = $435.88 \text{ kJ mol}^{-1}$

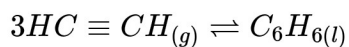
Enthalpy of bond dissociation of deuterium = $443.35 \text{ kJ mol}^{-1}$

$$E_H = E_D - 7.47$$

$$E_H \simeq E_D - 7.5$$

Thermodynamics

12. Assuming ideal behaviour, the magnitude of $\log K$ for the following reaction at 25°C is $x \times 10^{-1}$. The value of x is _____ (integer answer)



$$[\text{Given} : \Delta_f G^0(\text{HC} \equiv \text{CH}) = -2.04 \times 10^5 \text{ J mol}^{-1};$$

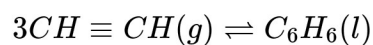
$$\Delta_f G^0(\text{C}_6\text{H}_6) = -1.24 \times 10^5 \text{ J mol}^{-1}; R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}]$$

Accepted Answers

855 855.0 855.00

Solution:

Answer : 855



$$\Delta G^0 = \Delta_f G^0(\text{C}_6\text{H}_6) - 3\Delta_f G^0(\text{CH} \equiv \text{CH})$$

$$= -1.24 \times 10^5 - 3(-2.04 \times 10^5)$$

$$= 4.88 \times 10^5 \text{ J mol}^{-1}$$

$$\Delta G^0 = -RT \ln K$$

$$= -2.303RT \log K$$

$$\log K = -\frac{4.88 \times 10^5}{2.303 \times 8.314 \times 298}$$

$$|\log K| = \frac{4.88 \times 10^5}{2.303 \times 8.314 \times 298}$$

$$|\log K| = 85.5$$

$$x \times 10^{-1} = 85.5$$

$$x = 855$$

Thermodynamics

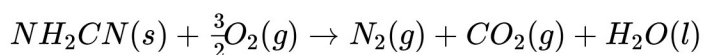
13. The reaction of cyanamide, $NH_2CN(s)$ with oxygen was run in a bomb calorimeter and ΔU was found to be $-742.24 \text{ kJ mol}^{-1}$. The magnitude of ΔH_{298} for the reaction $NH_2CN(s) + \frac{3}{2}O_2(g) \rightarrow N_2(g) + CO_2(g) + H_2O(l)$ is _____ kJ. (Rounded off to the nearest integer)

[Assume ideal gases and $R = 8.314 \text{ J mol}^{-1}K^{-1}$]

Accepted Answers

741 741.0 741.00

Solution:



$$\therefore \Delta H = \Delta U + \Delta n_g RT$$

$$\Delta n_g = 2 - \frac{3}{2} = 0.5$$

Assume that the ΔU is given at the same temperature.

$$\Delta H_{298} = -742.24 \text{ kJ} + \frac{0.5 \times 8.314 \times 298}{1000} \text{ kJ}$$

$$= -742.24 + 1.24$$

$$= -741 \text{ kJ}$$

$$|\Delta H_{298}| = 741 \text{ kJ}$$

Thermodynamics

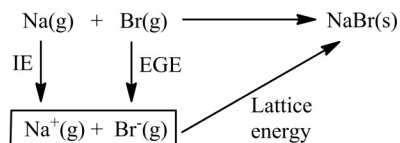
14. The ionization enthalpy of Na^+ formation from Na(g) is $495.8 \text{ kJ mol}^{-1}$, while the electron gain enthalpy of Br is $-325.0 \text{ kJ mol}^{-1}$. Given the lattice enthalpy of NaBr is $-728.4 \text{ kJ mol}^{-1}$. The energy for the formation of NaBr ionic solid from Na(g) and Br(g) is $(-)______ \times 10^{-1} \text{ kJ mol}^{-1}$

Accepted Answers

55765576.05576.00

Solution:

By Hess law, when there is more than one reaction, the total enthalpy change is the sum of the enthalpy changes of each reaction.



IE - Ionisation enthalpy

EGE - Electron gain enthalpy

The enthalpy of reaction of $\text{NaBr} = \text{IE} + \text{EGE} + \text{Lattice energy}$

$$\Delta_r H = 495.8 - 325 - 728.4$$

$$= -557.6 \text{ kJ/mol}$$

$$= -5576 \times 10^{-1} \text{ kJ/mol}$$

Hence, answer is 5576.

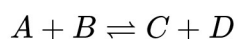
Thermodynamics

15. For a chemical reaction $A + B \rightleftharpoons C + D$ ($\Delta_r H^0 = 80 \text{ kJ mol}^{-1}$) the entropy change $\Delta_r S^0$ depends on the temperature T (in K) as $\Delta_r S^0 = 2T (\text{J K}^{-1} \text{ mol}^{-1})$. Minimum temperature at which it will become spontaneous is _____K (Integer)

Accepted Answers

200 200.0 200.00

Solution:



For the reaction to be spontaneous,

$$\Delta_r G < 0$$

$$\Delta_r G^0 < 0$$

$$\Rightarrow \Delta_r H^0 - T \times 2T < 0$$

$$\Rightarrow 80 \times 1000 - T \times 2T < 0$$

$$\Rightarrow T^2 > 40000$$

$$T > 200$$

$$\therefore \boxed{T_{\min} = 200 \text{ K}}$$

Thermodynamics

16. Five moles of an ideal gas at 293 K is expanded isothermally from an initial pressure of 2.1 MPa to 1.3 MPa against at constant external pressure 4.3 MPa. The heat transferred in this process is _____ $kJ\ mol^{-1}$.
(Rounded-off to the nearest integer)

$$[R = 8.314\ J\ mol^{-1}K^{-1}]$$

Accepted Answers

3 3.0 3.00

Solution:

For isothermal expansion at constant pressure, heat gained by the system is given by

$$Q = -W\ (\Delta U = 0)$$

$$W = -P\Delta V$$

$$Q = +P_{ex}(V_2 - V_1)$$

$$V_2 = \frac{nRT}{P_2}$$

$$V_1 = \frac{nRT}{P_1}$$

$$Q = P_{ex} \times n \times R \times T \left(\frac{1}{P_2} - \frac{1}{P_1} \right)$$

$$= 4.3 \times 5 \times 8.314 \times 293 \left[\frac{1}{1.3} - \frac{1}{2.1} \right]$$

$$= 15.345\ kJ\ mol^{-1}$$

Heat transferred per mole is :

$$q = \frac{15.345}{5} = 3.06 \approx 3\ kJ/mol$$

Thermodynamics

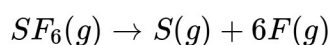
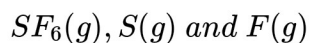
17. The average $S - F$ bond energy in kJ mol^{-1} of SF_6 is _____. (Rounded off to the nearest integer)

[Given : The values of standard enthalpy of formation of $\text{SF}_6(\text{g})$, $\text{S}(\text{g})$ and $\text{F}(\text{g})$ are - 1100, 275 and 80 kJ mol^{-1} respectively]

Accepted Answers

309 309.0 309.00

Solution:



$$\Delta H = \Delta H_f(\text{product}) - \Delta H_f(\text{reactant})$$

$$\Delta H^0 = \Delta H_f^0(\text{S}) + 6\Delta H_f^0(\text{F}) - \Delta H_f^0(\text{SF}_6)$$

$$= 275 + 6 \times 80 - (-1100)$$

$$= 1855 \text{ kJ mol}^{-1}$$

$$\text{Also, } \Delta H^0 = 6\Delta H_{S-F}$$

$$\therefore \Delta H_{S-F} = \frac{1855}{6} = 309.17 = 309 \text{ kJ mol}^{-1}$$

Thermodynamics

18. At 25°C , 50 g of iron reacts with HCl to form FeCl_2 . The evolved hydrogen gas expands against a constant pressure of 1 bar. The work done by the gas during this expansion is _____ J
(Round off to the Nearest Integer).

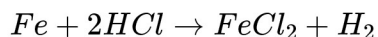
[Given : $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ Assume, hydrogen is an ideal gas]

[Atomic mass of Fe is 55.85 u]

Accepted Answers

22182218.02218.00

Solution:



$\frac{50}{55.85}$ moles of Fe reacts with HCl to form $\frac{50}{55.85}$ moles of H_2 .

No. of H_2 produced = $\frac{50}{55.85}$ moles

$$\text{Work done} = -P_{\text{ext}} \times \Delta V$$

$$= -\Delta n_g RT$$

$$= -\frac{50}{55.85} \times 8.314 \times 298$$

$$= -2218.05 \text{ J}$$

Nearest integer is 2218.

Thermodynamics

19. The standard enthalpies of formation of Al_2O_3 and CaO are $-1675 \text{ kJ mol}^{-1}$ and -635 kJ mol^{-1} respectively.

For the reaction,

$3CaO + 2Al \rightarrow 3Ca + Al_2O_3$ the standard reaction enthalpy, $\Delta_r H^0 = \underline{\hspace{2cm}}$ kJ (Rounded off to the Nearest Integer).

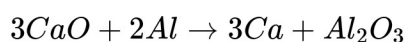
Accepted Answers

230 230.0 230.00

Solution:

$$\Delta H_f^0(Al_2O_3) = -1675 \text{ kJ mol}^{-1}$$

$$\Delta H_f^0(CaO) = -635 \text{ kJ mol}^{-1}$$



Al and Ca are in its standard state so enthalpy of formation of these elements is zero.

$$\therefore \Delta H_r^0 = \Delta H_f^0(Al_2O_3) - 3\Delta H_f^0(CaO)$$

$$\Delta H_r^0 = -1675 - 3(-635)$$

$$\Delta H_r^0 = 230 \text{ kJ}$$

20. For a given chemical reaction $A \rightarrow B$ at 300 K the free energy change is $-49.4 \text{ kJ mol}^{-1}$ and the enthalpy of reaction is 51.4 kJ mol^{-1} . The entropy change of the reaction is $\underline{\hspace{2cm}} \text{ J K}^{-1} \text{ mol}^{-1}$.

Accepted Answers

336 336.0 336.00

Solution:

$$\Delta G = -49.4 \text{ kJ/mol}$$

$$\Delta H = 51.4 \text{ kJ/mol}$$

$$\Delta G = \Delta H - T\Delta S$$

$$-49400 = 51400 - 300\Delta S$$

$$\Delta S = \frac{+100800}{300} = 336 \text{ J K}^{-1} \text{ mol}^{-1}$$

Thermodynamics

21. If the standard molar enthalpy change for combustion of graphite powder is $-2.48 \times 10^2 \text{ kJ mol}^{-1}$. the amount of heat generated on combustion of 1g of graphite powder in kJ is
(Nearest integer)

Accepted Answers

-21 -21.0 -21.00

Solution:

Heat of combustion per mol for 12 g = $-2.48 \times 10^2 \text{ kJ}$

For 1 g of graphite :

$$\text{Heat of combustion} = \frac{-2.48 \times 10^2}{12} = -20.66 \text{ kJ} \approx -21$$

22. For water $\Delta_{\text{vap}}H = 41 \text{ kJ mol}^{-1}$ at 373 K and 1 bar pressure. Assuming that water vapour is an ideal gas the that occupies a much larger volume than liquid water, the internal energy change during evaporation of water is ____ kJ mol^{-1} .
[Use : $R = 8.3 \text{ J mol}^{-1} \text{ K}^{-1}$]

Accepted Answers

38 38.0 38.00

Solution:



$$\Delta H = \Delta E + \Delta n_g RT$$

ΔE is internal energy change

Δn_g is change in gaseous moles = $1 - 0 = 1$

$$41 = \Delta E + 1 \times 8.3 \times 10^{-3} \times 373$$

$$\Delta E \approx (41 - 3) = 38 \text{ kJ mol}^{-1}$$

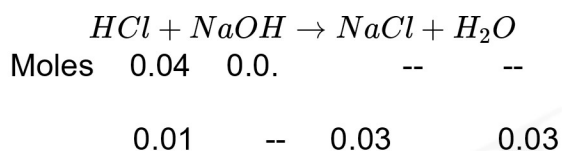
Thermodynamics

23. 200 mL of 0.2 M HCl is mixed with 300 mL of 0.1 M $NaOH$. The molar heat of neutralization of this reaction is -57.1 kJ . The increase in temperature in $^{\circ}C$ of the system on mixing is $x \times 10^{-2}$. The value of x is (Nearest integer)
 [Given: Specific heat of water = $4.18 \text{ J g}^{-1} \text{ K}^{-1}$ Density of water = 1.00 g cm^{-3}]
 [Assume no volume change on mixing]

Accepted Answers

82 82.0 82.00

Solution:



$$Q, \text{ Heat released} = 0.03 \times 57.1 \text{ kJ} = 1.713 \text{ kJ}$$

$$Q = m \times s \times \Delta T$$

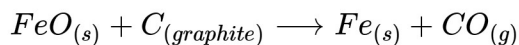
s is specific heat

$$\Delta T = \frac{1.713 \times 1000}{500 \times 4.18} = 81.96 \times 10^{-2} \approx 82 \times 10^{-2}$$

$$x = 82$$

Thermodynamics

24. Data given for the following reaction is as follows:



Substance	$\Delta_f H^\circ$ (kJ mol ⁻¹)	ΔS° (J mol ⁻¹ K ⁻¹)
$FeO_{(s)}$	-266.3	57.49
$C_{(graphite)}$	0	5.74
$Fe_{(s)}$	0	27.28
$CO_{(g)}$	-110.5	197.6

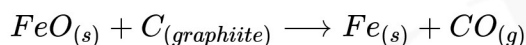
The
minimum

temperature in K at which the reaction becomes spontaneous is

Accepted Answers

964 964.0 964.00

Solution:



$$\Delta_f H^\circ(\text{reaction}) = (0 + (-110.5)) - (-266.3) = 155.8 \text{ kJ/mol}$$

$$\Delta S^\circ(\text{reaction}) = 27.28 + 197.6 - (57.49 + 5.74) = 224.88 = 63.23$$

$$\Delta S^\circ(\text{reaction}) = 161.65 \text{ J mol}^{-1} \text{ K}^{-1}$$

For spontaneity

$$\Delta G = \Delta H - T\Delta S \quad (\Delta G = 0)$$

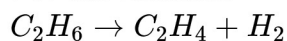
$$\Delta H = T\Delta S$$

$$T = \frac{\Delta H}{\Delta S} = \frac{155.8 \times 1000}{161.65} = 963.8 \text{ K}$$

$$\simeq 964 \text{ (nearest integer)}$$

Thermodynamics

25. For the reaction



the reaction enthalpy, $\Delta_r H$ _____ $kJ\ mol^{-1}$.

[Round off to the Nearest Integer]

[Given : Bond enthalpies in $kJ\ mol^{-1}$

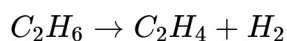
C - C : 347, C = C : 611;

C - H : 414, H - H : 436]

Accepted Answers

128 128.0 128.00

Solution:



$\Delta_r H$ = Sum of bond dissociation energy - Sum of bond formation energy

$$\Delta_r H = (B.E)_{C-C} + 6 \times (B.E)_{C-H} - [(B.E)_{C=C} + 4 \times (B.E)_{C-H} + (B.E)_{H-H}]$$

$$\Delta_r H = 347 + 6 \times 414 - (611 + 4 \times 414 + 436)$$

$$\Delta_r H = 2831 - 2703$$

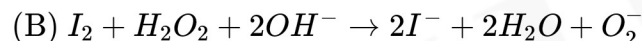
$$\Delta_r H = 128\ kJ\ mol^{-1}$$

1. (A) $\text{HOCl} + \text{H}_2\text{O}_2 \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- + \text{O}_2$
 (B) $\text{I}_2 + \text{H}_2\text{O}_2 + 2\text{OH}^- \rightarrow 2\text{I}^- + 2\text{H}_2\text{O} + \text{O}_2^-$

Choose the correct option.

- ☒ A. H_2O_2 acts as oxidising agent in equations (A) and (B).
☒ B. H_2O_2 act as oxidizing and reducing agent respectively in equation (A) and (B).
☒ C. H_2O_2 acts as reducing agent in equations (A) and (B).
☒ D. H_2O_2 acts as reducing and oxidising agent respectively in equationa (A) and (B).
 (A) $\text{HOCl} + \text{H}_2\text{O}_2 \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- + \text{O}_2$

In this equation, H_2O_2 is reducing chlorine from +1 to -1.



In this equation, H_2O_2 is reducing iodine from 0 to -1.

In (A) reduction of HOCl occurs so it will be a oxidising agent and H_2O_2 will be a reducing agent.

In (B) reduction of I_2 occurs so it will be a oxidising agent and H_2O_2 will be a reducing agent.

Option (c) is correct

2. Which of the following equation depicts the oxidizing nature of H_2O_2 ?

- ☒ A. $2I^- + H_2O_2 + 2H^+ \rightarrow I_2 + 2H_2O$
- ☐ B. $KIO_4 + H_2O_2 \rightarrow KIO_3 + H_2O + O_2$
- ☐ C. $Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$
- ☐ D. $I_2 + H_2O_2 + 2OH^- \rightarrow 2I^- + 2H_2O + O_2$

Equation (a)



In above reaction, H_2O_2 oxidises I^- to I_2 and itself gets reduced to H_2O so, this reaction depicts oxidising nature of H_2O_2

In equation (b) iodine gets reduced to +7 to +5 state.

In equation (c) chlorine gets reduced to 0 to -1 state

In equation (d) iodine gets reduced to +0 to -1 state.

Equations in options (b) , (c), (d) depict the reducing nature of H_2O_2

Option (a) is correct

3. Given below are two statements :

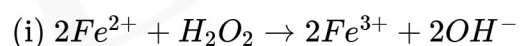
Statement I : H_2O_2 can act as both oxidising and reducing agent in basic medium.

Statement II : In the hydrogen economy, the energy is transmitted in the form of dihydrogen.

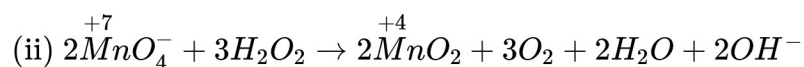
In the light of the above statement, choose the correct answer from the options given below:

- ☒ A. Both statement I and statement II are false
- ☒ B. Statement I is true but statement II is false
- ☒ C. Both statement I and statement II are true
- ☒ D. Statement I is false but statement II is true

(a) H_2O_2 can acts as both oxidising and reducing agent in basic medium.



In this reaction, H_2O_2 acts as oxidizing agent.



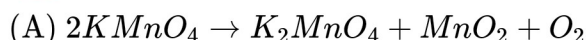
In this reaction, H_2O_2 acts as reducing agent.

(b) The basic principle of hydrogen economy is the transportation and storage of energy in the form of liquids or gaseous dihydrogen.

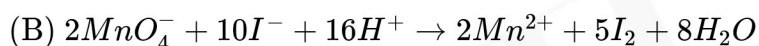
Advantage of hydrogen economy is that energy is transmitted in the form of dihydrogen and not as electric power

4. An example of a disproportionation reaction is:

- ☒ A. $2KMnO_4 \rightarrow K_2MnO_4 + MnO_2 + O_2$
- ☒ B. $2MnO_4^- + 10I^- + 16H^+ \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$
- ☒ C. $2CuBr \rightarrow CuBr_2 + Cu$
- ☒ D. $2NaBr + Cl_2 \rightarrow 2NaCl + Br_2$

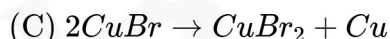


-In this reaction, manganese has +7 oxidation state in $KMnO_4$ and +6 and +4 oxidation states in K_2MnO_4 and MnO_2 respectively. This indicates manganese is only getting reduced. So, this reaction is not a disproportionation reaction.

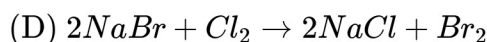


-In this reaction, manganese has +7 oxidation state in MnO_4^- and +2 oxidation state in the product side.

Thus, in this reaction as well manganese is getting reduced. So, this reaction is not a disproportionation reaction.



-In this reaction, copper is +1 in $CuBr$ and +2 oxidation state in $CuBr_2$ and zero oxidation state elemental form. This implies, In this reaction copper is getting both oxidized as well as reduced. Therefore, this reaction is an example of a disproportionation reaction.



In this reaction, sodium is +1 in both the reactant side as well as the product side. This is just an example of a displacement reaction not a disproportionation reaction.

5. In order to oxidise a mixture of one mole of each of FeC_2O_4 , $Fe_2(C_2O_4)_3$, $FeSO_4$ and $Fe_2(SO_4)_3$ in acidic medium, the number of moles of $KMnO_4$ required is :

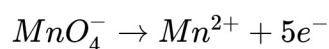
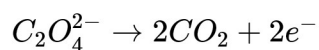
☒ A. 2

☐ B. 1

☐ C. 3

☐ D. 1.5

Change in oxidation state for respective species:



There will be no change in the oxidation state of $Fe_2(SO_4)_3$ as Fe is already in the highest oxidation state.

Using equivalence concept:

$$n_{eq}(KMnO_4) = n_{eq}[FeC_2O_4] + n_{eq}[Fe_2(C_2O_4)_3] + n_{eq}[FeSO_4]$$

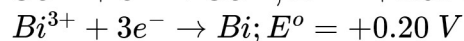
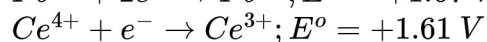
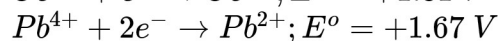
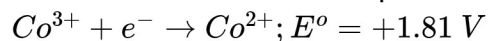
Let n be the number of moles of $KMnO_4$

$$n \times 5 = (1 \times 3) + (1 \times 6) + (1 \times 1)$$

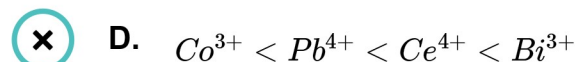
$$5n = 10$$

$$\therefore n = 2$$

6. Given standard reduction potentials:

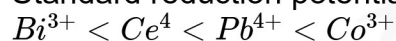


oxidizing power of the species will increase in the order:

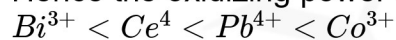


Lower the reduction potential, lower is the tendency of species to get reduced and hence less oxidizing power.

Standard reduction potential increases in the order:



Hence the oxidizing power of the species will increase in the same order i.e.



7. Given that $E_{O_2/H_2O}^o = +1.23V$;

$$E_{S_2O_8^{2-}/SO_4^{2-}}^o = 2.05V$$

$$E_{Br_2/Br^-}^o = +1.09V$$

$$E_{Au^{3+}/Au}^o = +1.4V$$

The strongest oxidising agent is:

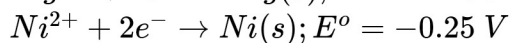
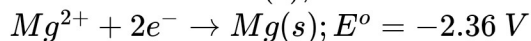
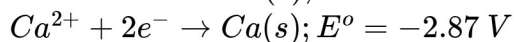
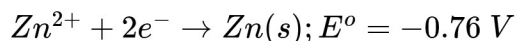
- ☒ A. Au^{3+}
- ☒ B. O_2
- ☒ C. $S_2O_8^{2-}$
- ☒ D. Br_2

$S_2O_8^{2-}$ is correct

Higher the reduction potential of the species, stronger oxidising power is of the species.

The standard reduction potential is the highest for $S_2O_8^{2-}$ to SO_4^{2-} .

8. Consider the following reduction processes:



The reducing power of the metals increases in the order:

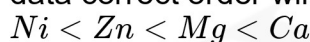
☐ A. $\text{Ca} < \text{Zn} < \text{Mg} < \text{Ni}$

☒ B. $\text{Ni} < \text{Zn} < \text{Mg} < \text{Ca}$

☐ C. $\text{Zn} < \text{Mg} < \text{Ni} < \text{Ca}$

☐ D. $\text{Ca} < \text{Mg} < \text{Zn} < \text{Ni}$

Lower the reduction potential, higher is the tendency of the species to get oxidised and hence better will be reducing power. So, according to the given data correct order will be:



9. In the reaction of oxalate with permanganate in acidic medium, the number of electrons involved in producing one molecule of CO_2 is:

☒ A. 1

☐ B. 10

☐ C. 2

☐ D. 5

The balanced reaction of oxalate with permanganate in an acidic medium is



The number of electrons involved in producing one molecule of CO_2 are :

$$= \frac{\text{No. of electron involved in balanced reaction}}{\text{No. of moles of } \text{CO}_2 \text{ produced}} = \frac{10}{10} = 1$$

10. Iodine reacts with concentrated HNO_3 to yield Y along with other products. The oxidation state of iodine in Y, is

- ☒ A. 5
☐ B. 3
☐ C. 1
☐ D. 7

The reaction of Iodine with concentrated nitric acid is given by -
 $I_2 + 10HNO_3 \rightarrow 2HIO_3 + 10NO_2 + 4H_2O$

The product Y is HIO_3

The oxidation state of Y from HIO_3 can be found as -

As the hydrogen = +1

And one Oxygen atom = -2

Thus, three oxygen atoms = -6

And for I be it's 'x'.

So, the oxidation state can be found as

$$1 + x + (-6) = 0$$

$$1 + x - 6 = 0$$

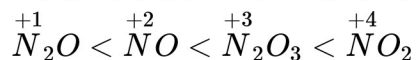
$$x = 6 - 1$$

$$x = 5$$

11. The correct increasing order of the oxidation states of nitrogen in NO , N_2O , NO_2 and N_2O_3 is:

- ☐ A. $NO_2 < NO < N_2O_3 < N_2O$
☒ B. $N_2O < NO < N_2O_3 < NO_2$
☐ C. $NO_2 < N_2O_3 < NO < N_2O$
☐ D. $N_2O < N_2O_3 < NO < NO_2$

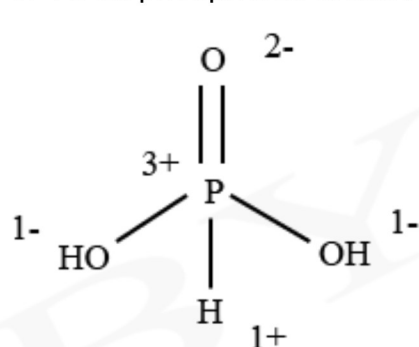
Correct order of oxidation state of nitrogen in oxides of nitrogen is following:



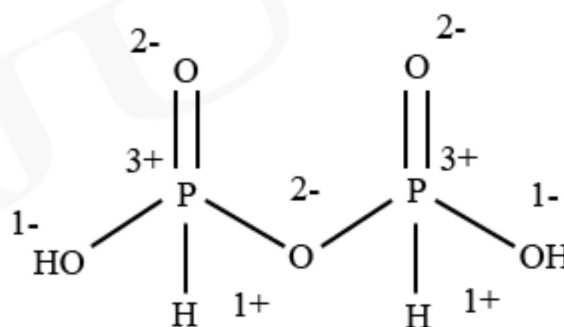
12. The pair in which phosphorus atoms have a formal oxidation state of +3 is :-

- ☐ A. Pyrophosphorus and pyrophosphoric acids
- ☒ B. Orthophosphorus and pyrophosphorus acids
- ☐ C. Pyrophosphorus and hypophosphoric acid
- ☐ D. Orthophosphorus and hypophosphoric acids

In oxoacids, phosphorus is tetrahedrally surrounded by other atoms. All these acids contain atleast one P = O and one P - OH bond. The oxoacids in which phosphorus has lower oxidation state (less than +5) contain, in addition to P=O and P-OH bonds, either P-P or P-H bond are present. Here, Orthophosphorus acid(H_3PO_3) and pyrophosphorus acid($H_4P_2O_5$) have a formal oxidation state of +3 on phosphorus atoms.



Ortho phosphorous acid



pyrophosphorous acid

13. The species given below that does *NOT* show disproportionation reaction is:

- ☐ A. BrO_3^-
- ☐ B. BrO^-
- ☐ C. BrO_2^-
- ☒ D. BrO_4^-

A reaction in which atoms of same element is simultaneously oxidised as well as reduced is called a disproportionation reaction. In BrO_4^- , Br is in the highest oxidation state of +7, so it cannot oxidise further. Hence, it cannot show disproportionation reaction.

14. The correct order of following 3d metal oxides, according to their oxidation number is:

- (a) CrO_3
- (b) Fe_2O_3
- (c) MnO_2
- (d) V_2O_5
- (e) Cu_2O

☒ A. $(a) > (d) > (c) > (b) > (e)$

☐ B. $(d) > (a) > (b) > (c) > (e)$

☐ C. $(a) > (c) > (d) > (b) > (e)$

☐ D. $(c) > (a) > (d) > (e) > (b)$

(a) CrO_3^{+6}

(b) $Fe_2O_3^{+3}$

(c) MnO_2^{+4}

(d) $V_2O_5^{+5}$

(e) Cu_2O^{+1}

So, the order of oxidation state is
 $a > d > c > b > e$

15. The oxidation states of 'P' in $H_4P_2O_7$, $H_4P_2O_5$ and $H_4P_2O_6$, respectively are:

☐ A. 5, 4 and 3

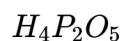
☐ B. 7, 5 and 6

☐ C. 6, 4 and 5

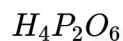
☒ D. 5, 3 and 4

Let the oxidation state of P in the above compounds be 'x'. Then, the value of x for the respective compounds can be calculated as,
 $H_4P_2O_7$

$$\begin{aligned} 4 + 2x - 14 &= 0 \\ 2x &= 10 \\ x &= +5 \end{aligned}$$



$$\begin{aligned} 4 + 2x - 10 &= 0 \\ 2x &= 6 \\ x &= +3 \end{aligned}$$



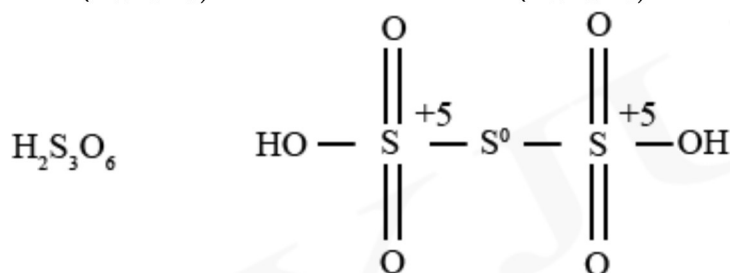
$$\begin{aligned} 4 + 2x - 12 &= 0 \\ 2x &= 8 \\ x &= +4 \end{aligned}$$

16. In polythionic acid, $H_2S_xO_6$ ($x = 3$ to 5) the oxidation state(s) of sulphur is/are :

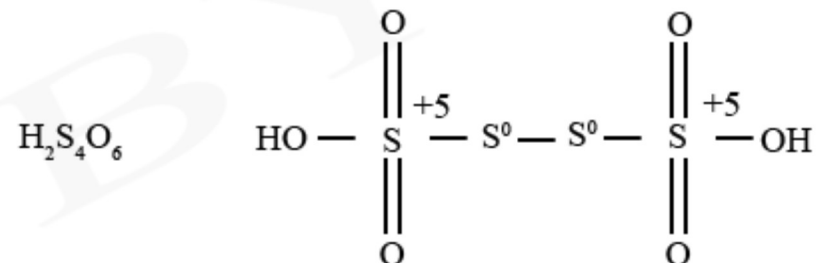
- ☒ A. 0 and +5 only
- ☐ B. +5 only
- ☐ C. +6 only
- ☐ D. +3 and +5 only

Polythionic acid is an oxoacid which has a straight chain of sulfur atoms and has the chemical formula $S_n(SO_3H)_2$ ($n > 2$)

For $H_2S_xO_6$ ($x = 3$ to 5), there are two polythionic acids possible, i.e., trithionic acid ($H_2S_3O_6$) and tetrathionic acid ($H_2S_4O_6$)



Therefore, the



oxidation states of Sulphur are 0 and +5 only.

17. Hydrogen peroxide reacts with iodine in basic medium to give:

- ☒ A. IO_3^-
- ☒ B. IO^-
- ☒ C. I^-
- ☒ D. IO_4^-

In a basic medium when an iodine solution reacts with Hydrogen peroxide it gives iodide ions along with water and oxygen. Because of its instability, hydrogen peroxide easily decomposes either to water or oxygen molecules. The oxidation state of oxygen in hydrogen peroxide is -1 . It can be oxidised to oxygen or reduced to water or hydroxide ion. In aqueous solution, hydrogen peroxide differs from pure substance due to the effects of hydrogen bonding between water and hydrogen peroxide molecules.

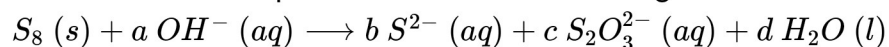
The conversion of iodine is due to the oxidizing action of the hydrogen peroxide. The reaction takes place like:



It clearly shows that when iodine is treated with hydrogen peroxide in the basic medium it gives iodide ions whereas when treated in an acidic medium it gives iodate ions.

Therefore for the aforesaid question the product of the reaction is I^- .

18. The reaction of sulphur in alkaline medium is given below:

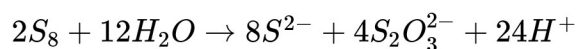
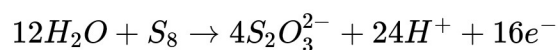
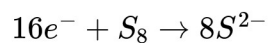


The value of a is (Integer answer)

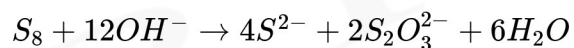
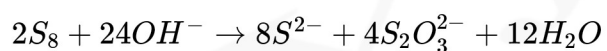
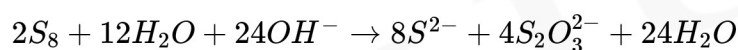
Accepted Answers

12 12.0 12.00

Solution:



For balancing in basic medium add an equal number of OH^- that of H^+



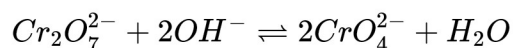
$$\therefore a = 12$$

19. Dichromate ion is treated with base, the oxidation number of Cr in the product formed is

Accepted Answers

6 6.0 6.00

Solution:



For CrO_4^{2-}

$$x + (-2 \times 4) = -2$$

$$x = 6$$

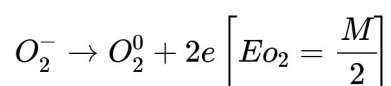
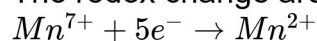
20. A 20.0 mL solution containing 0.2 g impure H_2O_2 reacts completely with 0.316 g of $KMnO_4$ in acid solution. The purity of H_2O_2 (in%) is (Nearest integer) (mol.wt.of H_2O_2 = 34, mole.wt.of $KMnO_4$ = 158)

Accepted Answers

85 85.0 85.00

Solution:

The redox change are:

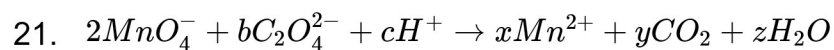


$$\therefore \text{Meq. of } H_2O_2 = \text{Meq. of } KMnO_4$$

$$\frac{w \times 10000}{\frac{34}{2}} = \frac{0.316}{\frac{158}{5}} \times 1000$$

$$\therefore {}^wH_2O_2 = 0.17 \text{ g}$$

$$\therefore \% \text{ purity of sample } H_2O_2 = \frac{0.17 \times 100}{0.2} = 85\%$$



If the above equation is balanced with integer coefficients, the value of c is
 (Round off to the nearest Integer)

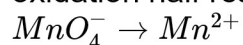
Accepted Answers

16

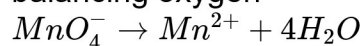
Solution:

Writing the half reaction

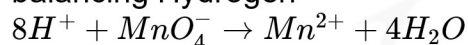
oxidation half reaction



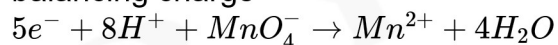
balancing oxygen



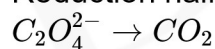
balancing Hydrogen



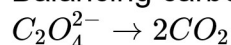
balancing charge



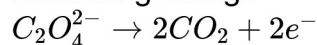
Reduction half



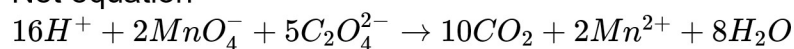
Balancing carbon



Balancing charge



Net equation



So c = 16

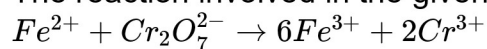
22. When 10 mL of an aqueous solution of Fe^{2+} ions was titrated in the presence of dil H_2SO_4 using diphenylamine indicator, 15 mL of 0.02 M solution of $K_2Cr_2O_7$ was required to get the end point. The molarity of the solution containing Fe^{2+} ions is $x \times 10^{-2}M$. The value of x is _____. (Nearest integer)

Accepted Answers

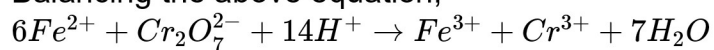
18

Solution:

The reaction involved in the given titration is,



Balancing the above equation,



milli-equivalents of Fe^{2+} = milli-equivalents of $K_2Cr_2O_7$

$$M \times 10 \times 1 = 0.02 \times 15 \times 6$$

$$M = 0.18 = 18 \times 10^{-2}M$$

23. In basic medium, CrO_4^{2-} oxidises $\text{S}_2\text{O}_3^{2-}$ to form $\text{Cr}(\text{OH})_4^-$ and SO_4^{2-} . How many mL(nearest integer) of $0.154 \text{ M } \text{CrO}_4^{2-}$ are required to react with 40.0 mL of $0.246 \text{ M } \text{S}_2\text{O}_3^{2-}$?

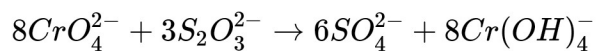
[Hint : $0.154 \text{ M} = 0.154 \times 3 \text{ N } \text{CrO}_4^{2-}$ and $0.246 \text{ M} = 0.246 \times 8 \text{ N } \text{S}_2\text{O}_3^{2-}$]

Accepted Answers

170

Solution:

The reaction is as follows:



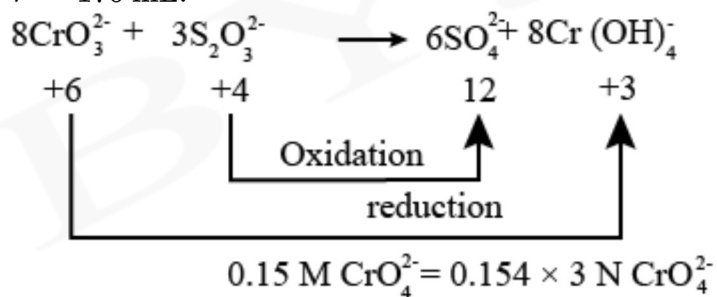
The normality of $0.154 \text{ M } \text{CrO}_4^{2-}$ is $0.154 \times 3 \text{ N}$.

Similarly, the normality of $0.246 \text{ M } \text{S}_2\text{O}_3^{2-}$ solution is $0.246 \times 8 \text{ N}$.

$$N_1 V_1 = N_2 V_2$$

$$V \times 0.154 \times 3 = 0.246 \times 8 \times 40$$

$$V = 170 \text{ mL.}$$



24. The oxidation states of transition metal atoms in $K_2Cr_2O_7$, $KMnO_4$ and K_2FeO_4 , respectively, are x , y and z . The sum of x , y and z is:

Accepted Answers

19

Solution:

$$\begin{aligned} K_2Cr_2O_7 \\ 2(+1) + 2x + 7(-2) &= 0 \\ x &= +6 \end{aligned}$$

$$\begin{aligned} KMnO_4 \\ (+1) + y + 4(-2) &= 0 \\ y &= +7 \end{aligned}$$

$$\begin{aligned} K_2FeO_4 \\ 2(+1) + z + 4(-2) &= 0 \\ z &= +6 \end{aligned}$$

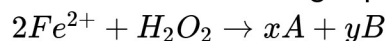
$$\text{So, } x = 6$$

$$y = 7$$

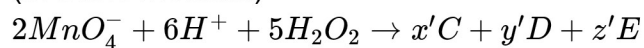
$$z = 6$$

$$\text{Therefore, } x + y + z = 19$$

25. Consider the following equations:



(in basic medium)



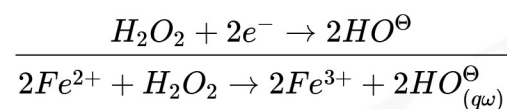
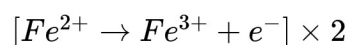
(in acidic medium)

The sum of the stoichiometric coefficients x, y, x', y' and z' for products A, B, C, D and E , respectively, is

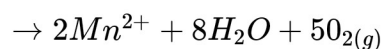
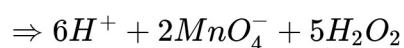
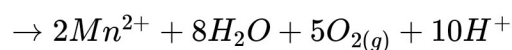
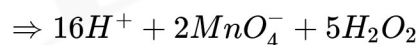
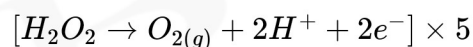
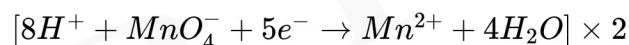
Accepted Answers

19

Solution:



$$x = 2 \quad y = 2$$



$$\text{So } x' = 2 \quad y' = 8 \quad z' = 5$$

$$\text{So } x + y + x' + y' + z'$$

$$= 2 + 2 + 2 + 8 + 5$$

$$= 19$$