Solved problems
Chapter -14

,asic Concepts:

13-1. Explain the difference between electric charge (q, Coulombs), electric current (I, amperes), and electric potential (E, volts).

Ans:

Electric charge:

Electric charge (Coulombs) refers to the quantity of +ve or -ve particles.

Electric current:

Current (amperes) is the quantity of charge moving past a point in a circuit each second

Electric potential:

Electric potential (volts) measures the work that can be done by each coulomb of charge as it moves from one point to another.

13-2 ~~13-2~~. (a) How many electrons are in one Coulomb?

$$\frac{1}{1.602\,17642 \times 10^{-19}\ C/\text{electrons}}$$

$$= 6.24150975 \times 10^{18}\ \text{electrons}/C.$$

(b) How many coulombs are in one mole of charge?

$$F = \frac{96485.3415\ C}{mol.}$$

13-4 ~~13-4~~. A 6.00 V battery is connected across a 2.00-kΩ resistor.

(a) How many electrons per second flow through the circuit?

(b) How many joules of heat are produced for each electron?

(c) If the circuit operates for 30.0 min, how many moles of electrons will have flowed through the resistor?

(d) what voltage would the battery need to deliver for the power to be 1.00×10^{2} W?

Ans:

(a) $I = \frac{E}{R}$

$$I = \frac{6.00\,V}{2.0 \times 10^{3}\,\Omega} = 3.00\ mA$$

$$I_{current} = 3.00 \times 10^{-3}\ C/s$$

$$\therefore q_{charge} = I \times t$$

$$= 3.00 \times 10^{-3}\ C/\cancel{s} \times 1\cancel{s}$$

$$q = 3.00 \times 10^{-3}\ C$$

Charge of $e^{-} = 1.6 \times 10^{-19}$ C

Number of electrons per second flow through the circuit

$$= \frac{q}{e^{-}} = \frac{3.00 \times 10^{-3}\ C}{1.6 \times 10^{-19}\ C}$$

$$= 1.87 \times 10^{16}\ e^{-}/s$$

(b) How many joules of heat are produced for each electron?

$$\text{Power} = E \times I$$

$$= (6.00\,V) \times (3.00 \times 10^{-3}\,A)$$

$$= 1.80 \times 10^{-2}\,W$$

$$= 1.80 \times 10^{-2}\,J/s.$$

Heat (J) produced for each electron

$$= \frac{P \text{ (Power)}}{\text{no. of } e^-/s}$$

$$= \frac{1.80 \times 10^{-2}\ J/s}{1.87 \times 10^{16}\ e^-/s}$$

$$\boxed{\text{Heat} = 9.63 \times 10^{-19}\ J/e^-}$$

$\therefore$ no. of e^-/s

$$= \frac{I}{\text{Charge of } e^-}$$

$$= \frac{3.00 \times 10^{-3}\ C/s}{1.6 \times 10^{-19}\ C}$$

$$= 1.87 \times 10^{16}$$

(c) If the circuit operates for 30.0 min, how many moles of electrons will have flowed through the resistor?

Ans:

30.0 min = 1800 s

no of e^- per s = 1.87×10^{16}

$\therefore$ no of e^- 30 min = $1800\,s \times (1.87 \times 10^{16})\,e^-/s$

$= 3.37 \times 10^{19}$ electrons.

$\therefore$ no of moles of e^- = $\dfrac{3.37 \times 10^{19} \text{ electrons.}}{6.023 \times 10^{23} \text{ ~~moles of electrons~~}}$

$= 5.60 \times 10^{-5}$ mol

$\because$ 1 mol = Avogadro's no of anything.

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(d) what voltage would the battery need to deliver for the power to be 1.00×10^2 W?

$$E = \sqrt{PR}$$

$$E = \sqrt{(100\,W)(2.00 \times 10^3\,\Omega)}$$

∴ E = voltage
P = power
R = Resistance

$$\boxed{E = 447\,V.}$$

13-5 ~~[illegible]~~. Consider the following redox reaction :

$$I_2 + 2S_2O_3^{2-} \rightleftharpoons 2I^- + S_4O_6^{2-}$$

Thiosulfate   Tetrathionate

(a) Identify the oxidising agent on the left side of the reaction and write a balanced oxidation half-reaction.

Ans ∴

$$I_2 + 2e^- \rightleftharpoons 2I^- \quad (I_2 \text{ is the oxidant})$$

(b) Identify the reducing agent of the left side of the reaction and write a balanced reduction half-reaction.

Ans ∴

$$2S_2O_3^{2-} \rightleftharpoons S_4O_6^{2-} + 2e^-$$

($S_2O_3^{2-}$ is the reductant).

(c) How many coulombs of charge are passed from reductant to oxidant when 1.00 g of thiosulfate reacts?

$$\frac{1.00\ g\ S_2O_3^{2-}}{112.12\ g/mol} = 8.92\ mmol\ S_2O_3^{2-}$$

$$= 8.92\ mmol\ e^-$$

$$\therefore (8.92 \times 10^{-3}\ \cancel{mol})\left(9.649 \times 10^4 \frac{C}{\cancel{mol}}\right)$$

$$= 861\ C$$

(d) If the rate of reaction is 1.00 g of thiosulfate consumed per minute, what current (in Amperes) flows from reductant to oxidant?

$$\text{current}(A) = \frac{\text{Coulombs}}{s}$$

$$= \frac{861\ C}{60\ s} = 14.3\ A$$

13-6. The space shuttles expendable booster engines derive their power from solid reactants:

$$6NH_4ClO_{4\,(s)} + 10Al_{(s)} \longrightarrow 3N_{2\,(g)} + 9H_2O_{(g)} + 5Al_2O_{3\,(s)} + 6HCl_{(g)}$$

FM 117.49

(a) Find the oxidation numbers of the elements N, Cl, and Al in reactants and products. Which reactants act as reducing agents and which act as oxidants?

Ans

Oxidation number of Reactants:

N (in NH_4^+)	Cl (in ClO_4^-)	Al
−3	+7	0

Oxidation number of products:

N	Cl	Al
0	−1	+3

NH_4^+ and Al are reducing agents and ClO_4^- is the oxidising agent.

(b) The heat of reaction is −9334 kJ for every 10 mol of Al consumed. Express this as heat released per gram of total reactants.

Ans

Formula mass of reactants

$$= 6(FM\ NH_4ClO_4) + 10(FM\ Al)$$

$$= 974.75$$

$$\therefore \text{Heat released per gram} = \frac{9334\ kJ}{974.75\ g}$$

$$= 9.576\ kJ/g.$$