Chemistry – Reactions

Reversible & Irreversible

– Balancing Chemical Equations
(Mass / Mol Balance)

Oxidation – reduction

Charges change on ions, radicals & functional groups

oxidation – Lose Electrons = Oxidize
Charge increases (+)
Occurs at anode

Reduction – Gain Electrons = Reduce
Charge decreases (–)
Occurs at cathode

In Redox
– Balanced equation + Balance Charge (0)

1.0. $2Na + Cl_2 \rightarrow 2NaCl$

$2Na \rightarrow 2Na^+ + 2e^-$
(oxidizes)

$2Cl + 2e^- \rightarrow 2Cl^-$
(reduces)

~~$2Na^+ + 2e^-$~~

Redox analyze

① Unbal eqn. all rx all products
② Oxidation Numbers to each atom
③ Note e^- required for each atom to ↑ + ↓ −
④ Balance eqn with e^-
⑤ Balance remainder as required

Reaction Rates

$$aA + bB \rightleftharpoons cC + dD$$

$$\text{rate} = \frac{\Delta \text{Conc}}{\Delta \text{time}}$$

law mass action (kinetic)

$$r_f = k_{forward}[A]^a[B]^b$$

$$r_r = k_{reverse}[C]^c[D]^d$$

Equilibrium

$$\frac{k_{forward}}{k_{reverse}} = K_{eq} = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

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~~Ideal~~ gasses use partial pressures

$$K_p = \frac{[P_{Prod}]^p}{[P_{rx_1}]^a[P_{rx_2}]^b}$$

$$K_p \neq K_{eq}$$

$$K_p = K_{eq}(\bar{R}T)^{\Delta n}$$ (moles)

Ideal gas

$$\rho = \frac{1}{v} = \frac{p}{RT}$$

Boyles Law: $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$

$$\rho V = \frac{m}{M} RT$$

$$pV = nRT$$

↑ gas constant

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0.08206 $\frac{L \cdot atm}{K \cdot mol}$

8314 J/kmol·K

Acids/Bases

Acids produce H^+ ions

Bases produce OH^- ions (or accept H^+ ions)

The ~~strength~~ of acid is

$[H^+]$ usually expressed as $pH = -\log_{10}[H^+]$

" of base is

$[OH^-]$ usually expressed as $pOH = -\log_{10}[OH^-]$

Note: Be able to compute pH of ~~simple~~ strong ~~acid~~ acids given mass.

HCl
H_2SO_4 etc
HClO

$HCl \rightleftharpoons H^+ + Cl^-$

assoc. is complete.

① Balance

$HBrO_3$ $HBr \rightarrow H_2O$ Br_2

(a) $HBrO_3 + 4HBr \rightarrow 3H_2O + Br_2$ x

(b) $2HBrO_3 + 4HBr \rightarrow 3H_2O + 3Br_2$?x

(c) $3HBrO_3 + HBr \rightarrow 2H_2O + 2Br_2$?x

(d) $HBrO_3 + 5HBr \rightarrow 3H_2O + 3Br_2$?✓

(i) Fastest to find WRONG ANSWERS.

a) ~~Hheck~~
Check H, Check O, Check oters.

Choose D

If you need to Balance.

Bal H with H

O with H_2O

oter with oter

(2) Solutn adjusted from pH8 to pH9
The relatn $[H^+]$ conc. has changed by what factor (ratio)?

a $1/100$

b $1/10$

c 5

d 10

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only possbles are b and d

$pH8 = [10^{-8}$

$pH9 = 10^{-9}$

$[H^+]$ is smaller

$\therefore \frac{1}{10}$, choose B

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(3) Hydrogen (H_2) and chlorine (Cl_2) gas are combined in 35 m^3 reactor to make HCL gas. Mass of H is 4.5kg mass Cl is 160 kg. How much HCL is produced?

(a) 21 kg
(b) 41 kg
(c) 82 kg
(d) 160 kg

Easy - vessel is reactor, closed system
∴ Total mass unchged
160 + 4.5 = 164.5 kg gas
Choose (d)

Hard way

$H_2 = \frac{4500g}{2g/mol} = 2250mol$

$Cl_2 = \frac{160,000g}{71g/mol} = 2254mol$

$H_2 + Cl_2 \rightarrow 2HCL$

∴ 4500 mol HCL

$4500\left(36.5\frac{g}{mol}\right) = 164250g$

164.25kg

Choose (d)

(4) O_3 decomposes into O_2 at 100°C

One mole O_3 sealed in container at 0°C, 1atm.

What is pressure in container when T = 100°C?

(a) 1.4 kPa

(b) 2.1 kPa

(c) 137. kPa

(d) 210 kPa

$$O_3 \rightarrow O_2$$

balance

$$2O_3 \Rightarrow 3O_2$$

$$O_3 \rightarrow \frac{3}{2}O_2$$

Ideal gas

$$\frac{P_1 V_1}{n_1 R T_1} = \frac{P_2 V_2}{n_2 R T_2}$$

$$\frac{n_2}{n_1}\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$\frac{n_2}{n_1}\frac{P_1 T_2}{T_1} = P_2$$

#'s

$$\frac{\frac{3}{2}(101\,kPa)(373\,K)}{1\ (273K)}$$

$$= 206.9\,kPa$$

Choose (d)

210 kPa

(5) Which are <u>not</u> a base in water?

I NH_3 (ammonia)

II Na_2CO_3 (sodium carbonate)

III $NaOH$ (sodium hydroxide)

IV C_6H_4COOH (acetic acid)

a) IV ✓

~~b) I & III X~~

~~c) II & III X~~

d) II & IV X

* Trick
- Use what you know
NaOH is base
Auto eliminate B/C

II $Na_2CO_3 + H_2O \rightarrow 2Na^+ + (CO_3)^{2-} + OH^-$

eliminate c) d)

I $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$

eliminate b)

Must b A

$C_6H_4COOH + H_2O \rightleftharpoons C_6H_5COO^- + H^+$

(6) 1L solution

52.7g H_2SO_4 MW 98

240.8g $KMnO_4$ MW 158

11.3g K_2SO_4 MW 174

5.5g Mn_2O_7 MW 222

MW H_2O = 18

$$H_2SO_4 + 2KMnO_4 \rightleftharpoons K_2SO_4 + Mn_2O_7 + H_2O$$

What is K_{eq}?

(a) $1.3 \cdot 10^{-3}$

(b) $2.6 \cdot 10^{-3}$

(c) $5.2 \cdot 10^{-3}$

(d) $6.9 \cdot 10^{-3}$

Permanganate Acid reaction (very oxidizing)

Check if Bal

+ Told a solution in water (Don't use H_2O in K_{eq})

$$K_{eq} = \frac{[K_2SO_4][Mn_2O_7][\cancel{H_2O}]}{[H_2SO_4][KMnO_4]^2}$$

$$= \frac{\cancel{[52.7/98]}}{} \frac{[11.3/174][5.5/222]}{[52.7/98][240.8/158]^2}$$

$$= \frac{[0.065][0.025]}{[0.5][1.52]^2} = 0.0014$$

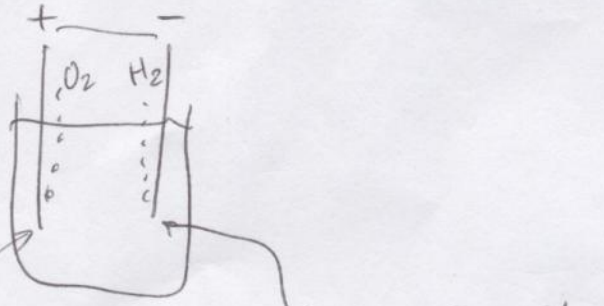
$1.4 \cdot 10^{-3}$

choose A

Redox

Electrolysis of water

$$H_2O \longrightarrow H_2 + \frac{1}{2} O_2$$



$H_2O \rightarrow \frac{1}{2} O_2 + 2H^+ + 2e^-$

$I = 100A$ how much O_2 is produced?

a) 8.29 mg/s

b) 9.34 mg/s

c) 16.7 mg/s

d) 18.7 mg/s

$100A =$

$1A = 1 \text{ Coulomb/sec}$

$\frac{1C}{sec} =$ ~~96485~~

$\frac{1C}{sec} \cdot \frac{mol}{96485C} = \frac{\#mols\ e^-}{sec}$

$\frac{100C\ mol}{96485C\ sec}\ e^-$ passed

$\frac{100\ mol}{96485} * \frac{\frac{1}{2} mol\ O_2}{2 mol\ e^-} = 0.000259 mol\ O_2/sec$

$0.000259 \frac{mol O_2}{sec} \frac{32g}{1 mol O_2} = 0.00829 g\ O_2/sec$

$= 8.29 mg/s$

Choose A