Eq Asmt
[44 marks]

$\left(\dfrac{40.5}{44}\right)$ yowza!

Communication [3 marks] ③

1. The reaction of N_2 with O_2 to form NO might be considered a means of 'fixing' nitrogen:

$$N_2(g) + O_2(g) \leftrightarrow 2NO(g)$$
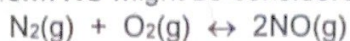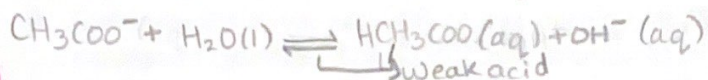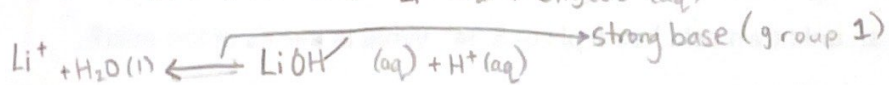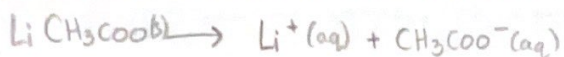
The value for the equilibrium constant for this reaction at 25°C is $K_c=1 \times 10^{-30}$. Discuss the feasibility of this reaction for nitrogen fixation. [3 marks]

1×10^{-30} is very small, so a very small product to reactant ratio. Very little nitrogen is fixed, so most of it stays as $N_2(g)+O_2(g)$

3

Making Connections [8 marks] ⑧

2. Will lithium acetate form an acidic or basic solution? Explain your reasoning. [3 marks]

$LiCH_3COObl \longrightarrow Li^+(aq) + CH_3COO^-(aq)$

$Li^+ + H_2O(l) \xleftrightarrow{\quad} LiOH(aq) + H^+(aq) \rightarrow$ strong base (group 1)

$CH_3COO^- + H_2O(l) \xrightleftharpoons{} HCH_3COO(aq) + OH^-(aq) \rightarrow$ weak acid

3

∴, $LiCH_3COO$ is basic, because LiOH is a strong base, and will overpower HCH_3COO, which is a weak acid

3. For the reaction, $PBr_5(g) \xleftrightarrow{heat+} PBr_3(g) + Br_2(g)$, in what direction will the equilibrium shift when the following actions are taken on the system at equilibrium? [5 marks]

(a) $Br_2(g)$ is removed   right ✓

(b) the temperature is decreased   left ✓

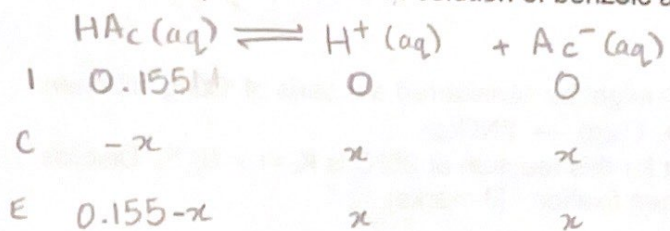(c) the volume of the reaction system is decreased   left ✓

(d) a catalyst is added   none ✓

(e) $PBr_5(g)$ is removed   left ✓

5

Inquiry [19 marks] [17]

4. Calculate the pH of a 0.155 M solution of benzoic acid.   [8 marks]

$$HAc\ (aq) \rightleftharpoons H^+\ (aq) + Ac^-\ (aq)$$

I	0.155M	0	0
C	$-x$	x	x
E	$0.155-x$	x	x

K_a benzoic acid $= 6.6 \times 10^{-5}$

$$K_a = \frac{[H^+][Ac^-]}{[HAc]}$$

$$6.6 \times 10^{-5} = \frac{x^2}{0.155-x}$$

$$x = \sqrt{(0.155)(6.6 \times 10^{-5})}$$

$$x = 0.00001023M$$

$$x = 1.02 \times 10^{-5}$$

$= 3.2 \times 10^{-3}$

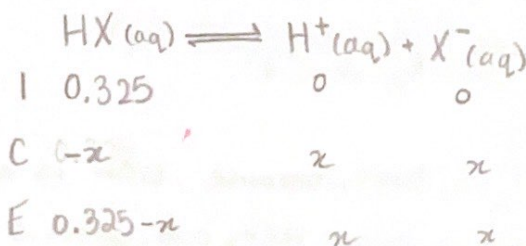$$[H^+] = 1.02 \times 10^{-5}$$
$$pH = -\log(1.02 \times 10^{-5} M)$$
$$pH = 4.99$$
$$\boxed{pH = 5.0}$$

$$pH = -\log(3.2 \times 10^{-3})$$
$$= 2.49$$

5. A 0.325 M solution of an unknown acid has a pH of 5.34. What is the K_a of the acid?
   [8 marks]

$C = 0.325M$
$pH = 5.34$
$K_a = ?$

$$HX\ (aq) \rightleftharpoons H^+(aq) + X^-(aq)$$

I	0.325	0	0
C	$(-x)$	x	x
E	$0.325-x$	x	x

① $$K_a = \frac{[H^+][X^-]}{[HX]} = \frac{x^2}{0.325-x}$$

② $pH = \log[H^+]$

$$[H^+] = 10^{-pH} = 10^{-5.34}$$

$$[H^+] = 4.57 \times 10^{-6}$$

③ $$x = 4.57 \times 10^{-6}$$

$$\frac{(4.57 \times 10^{-6})^2}{0.325} = K_a$$

$$\boxed{K_a = 6.42 \times 10^{-9}}$$

alculate the pH of a buffer that is 0.25 M in lactic acid, $HC_3H_5O_3$ ($K_a = 1.4 \times 10^{-4}$) and 0.20 M in sodium lactate, $NaC_3H_5O_3$. [3 marks]

$\leftarrow HC_3H_5O_3 \qquad\qquad NaC_3H_5O_3 \rightarrow base$

$pKa = -\log Ka$
$= -\log(1.4\times10^{-4})$
$\boxed{3.85}$

$0.25M \qquad\qquad\qquad 0.2M$

3

① $pH = pKa + \log\left(\dfrac{[NaC_3H_5O_3]}{[HC_3H_5O_3]}\right) \longrightarrow$ ② $pH = 3.85 + \log\left(\dfrac{0.2}{0.25}\right)$
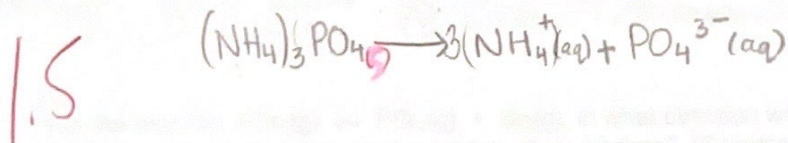
③ $pH = 3.85 + (0.0969) = \boxed{3.75}$

Knowledge & Understanding [14 marks] (2s)

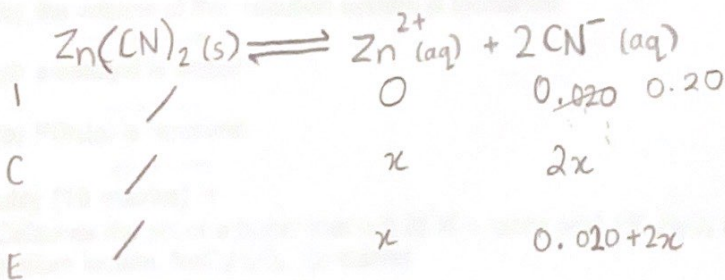7. Show the neutralization reaction between sulfuric acid and potassium hydroxide. [4 marks]

4

$$H_2SO_4\,(aq) + 2KOH^{(aq)} \longrightarrow K_2SO_4 + 2H_2O\,(l)$$
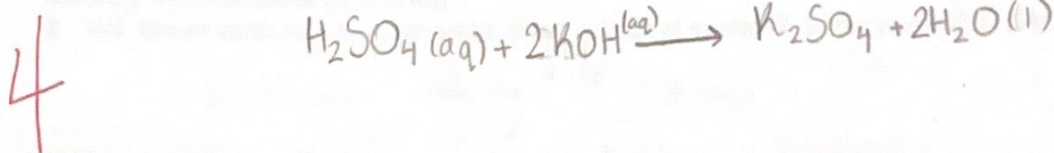
8. Show the dissociation of ammonium phosphate in water. [2 marks]

1.5

$$(NH_4)_3PO_4 \longrightarrow 3(NH_4^+)(aq) + PO_4^{3-}\,(aq)$$

9. Calculate the molar solubility of zinc cyanide, at 25°C, in the presence of 0.20 M potassium cyanide. The K_{sp} for zinc cyanide at 25°C is 8.0×10^{-12}. [8 marks]

$K_{sp} = 8.0 \times 10^{-12}$

$$Zn(CN)_2\,(s) \rightleftharpoons Zn^{2+}_{(aq)} + 2CN^-\,(aq)$$

I	/	O	0.020 0.20
C	/	x	$2x$
E	/	x	$0.020 + 2x$

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$K_{sp} = [CN^-]^2[Zn^{2+}]$

$8.0 \times 10^{-12} = (0.020 + 2x)^2 (x)$

$8.0 \times 10^{-12} = 0.0004x$

$x = 0.00000002 = 2.0 \times 10^{-8}$ M $\dfrac{mol}{L}$

$\therefore$ molar solubility of $Zn(CN)_2$ is $\boxed{2.0 \times 10^{-8}\ M}$