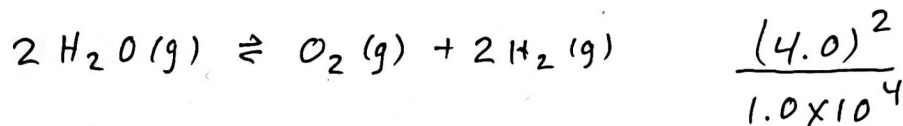
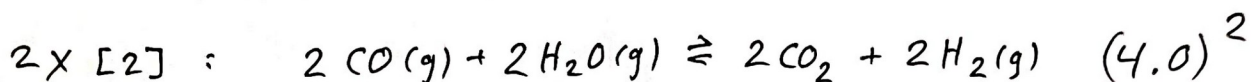
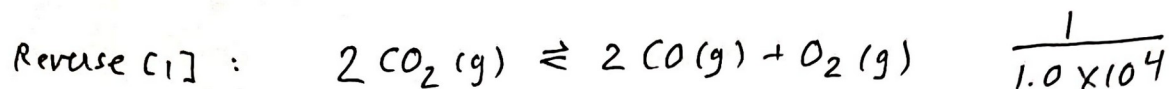
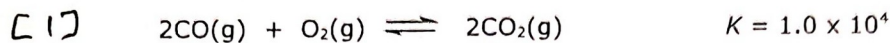
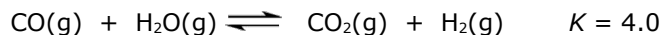
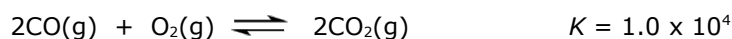


Solution Test 2

Question 1

- a. Calculate the equilibrium constant for: $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{O}_2(\text{g}) + 2\text{H}_2(\text{g})$ at 25 °C using the following two equilibrium. (3 marks)



$$K = 1.6 \times 10^{-3}$$

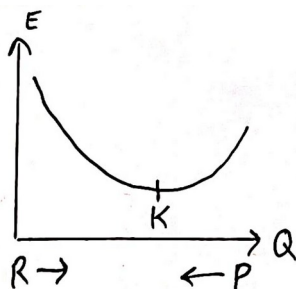
- Match each of the following "equilibrium condition" for a system, with one of the available answers. (note: the same answer can be used more than once) (3 marks)

Equilibrium condition

b. $Q < K$

c. $K \approx 1$

d. $Q = K$



Possible answer

i) Reaction is at equilibrium.

ii) Reaction will favour formation of reactants

iii) Reaction favours formation of more product

iv) Reaction does not strongly favour reactants or products

answers: b. ____ iii ____ c. ____ iv ____ d. ____ i ____

Question 2

Consider the following equilibrium for the production of hydrogen gas from water:



100.0 g of water and 50.0 g of solid carbon are heated together (to 500.0 °C) in a 10.0 L container; calculate the mass of hydrogen gas produced once the equilibrium is reached. (4 marks)

$$[\text{H}_2\text{O}] = \frac{\frac{100.0 \text{ g}}{18.015 \text{ g}\cdot\text{mol}^{-1}}}{10.0 \text{ L}} = 0.555 \text{ M}$$

	H_2O	$\text{C}(\text{s})$	\rightleftharpoons	H_2	$+$	CO
I	0.555	solid		0		0
C	-x	-		+x		+x
E	0.555-x			x		x

$$K_c = \frac{[\text{H}_2][\text{CO}]}{[\text{H}_2\text{O}]}$$

(2 s.f.)

$$0.013 = \frac{(x)^2}{0.555-x}$$

Quadratic $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$0 = x^2 + 0.013x - 0.00722$$

\uparrow \uparrow \uparrow
 $a=1$ $b=+0.013$ c

$$x = \begin{cases} 0.0787 \leftarrow \text{yes} \\ -0.0917 \leftarrow \text{No!} \end{cases} \Rightarrow 0.0787 \frac{\text{mol}}{\text{L}} \times 10.0 \text{ L} \times 2.016 \text{ g/mol}$$

answer: _____ 1.6 g _____

g. What is the K_p value for this reaction at 500.0 °C?

(3 marks)

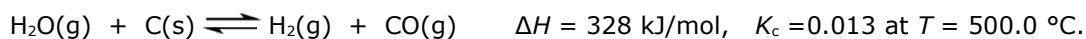
$$K_p = K_c (RT)^{\Delta n}$$

$$K_p = 0.013 \left[\left(0.08206 \frac{\text{L}\cdot\text{atm}}{\text{K}\cdot\text{mol}} \right) (273 + 500.) \text{K} \right]^{2-1} = 0.825$$

answer: _____ 0.83 _____

Question 3

Consider the same reaction as the one of the previous problem: (6 marks)



Predict qualitatively the change of concentration of CO(g) after the following changes of conditions.

	CO(g) amount (number of mole)		
	decreases	no change	increases
a. CO ₂ (g) is added to increase the pressure	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Some H ₂ O(g) condenses to form H ₂ O(l)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Increasing the size of the container	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. the reaction is heated	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. removing some C(s) from the reaction mixture	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
f. A catalyst is added	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Question 4

a. Which of the following strong acid aqueous solution has a pH of 2.22 (1 mark)

i) 0.25 g HI (130.6 g/mol) dissolved in 250 mL water

ii) 25 mL of 0.036 M HNO₃ added to 125 mL water

iii) 0.0050 mol of HClO₄ dissolved in 750 mL water

iv) none of the above

$$\frac{(25 \text{ mL})(0.036 \text{ M})}{(25 + 125) \text{ mL}} = 0.0060 \text{ M}$$

↓
pH = 2.22

answer: _____

b. What mass of KOH is necessary to prepare 750.0 mL of a solution having pH = 12.22? (3 marks)

at 25°C $\text{pH} + \text{pOH} = 14.00$

$$\text{pOH} = 14.00 - 12.22 = 1.78$$

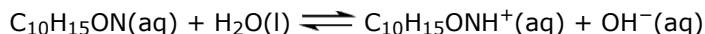
$$[\text{OH}^-] = 10^{-1.78} = 0.0166 \text{ M}$$

$$0.0166 \frac{\text{mol}}{\text{L}} \times 0.750 \text{ L} \times 56.11 \frac{\text{g}}{\text{mol}}$$

answer: _____ 0.70 g _____

Question 5

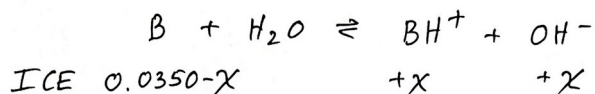
- a. Ephedrine, a central nervous system stimulant, is used in nasal sprays as a decongestant. This compound is a weak organic base:



A 0.0350 M solution of ephedrine has a pH of 11.33. Calculate K_b for ephedrine. (4 marks)

$$\text{pOH} = 14.00 - \text{pH} = 2.67$$

$$[\text{OH}^-] = 10^{-2.67} = 2.14 \times 10^{-3}$$

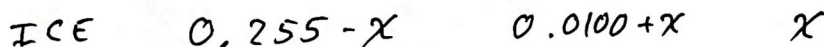
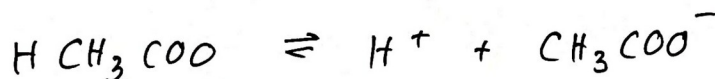


$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} = \frac{(x)^2}{0.0350 - x} = \frac{(2.14 \times 10^{-3})^2}{0.0350 - 0.00214} = 1.4 \times 10^{-4}$$

$$K_b = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} = \frac{(x)^2}{0.0350 - x} = \frac{(2.14 \times 10^{-3})^2}{0.0350 - 0.00214} = 1.4 \times 10^{-4}$$

answer: 1.4 × 10⁻⁴ (correct answer with 2 s.f.)

- b. Consider a mixture of 0.0100 M HCl and 0.255 M acetic acid, HCH₃COO. Calculate the concentration of the acetate ion(CH₃COO⁻) in this solution at equilibrium. (4 marks)



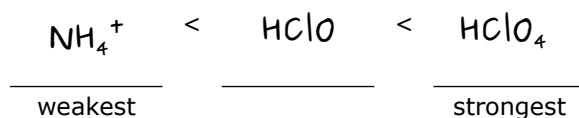
$$K_a = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{HCH}_3\text{COO}]} \Rightarrow 1.8 \times 10^{-5} = \frac{(0.0100 + x)(x)}{0.255 - x}$$

assuming $x \ll 0.01$ then

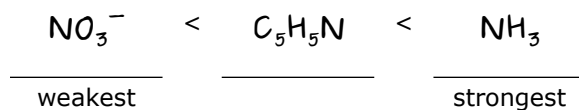
$$1.8 \times 10^{-5} = \frac{(0.0100)[\text{CH}_3\text{COO}^-]}{0.255} \Rightarrow [\text{CH}_3\text{COO}^-] = 4.59 \times 10^{-4} \text{ M}$$

Question 6

a. Order the following acids from the weakest to the strongest: HClO , NH_4^+ , HClO_4 (1 mark)



b. Order the following bases from the weakest to the strongest: NO_3^- , NH_3 , $\text{C}_5\text{H}_5\text{N}$ (1 mark)



c. Order the following salts from the most basic to the most acidic: KCN , KF , FeCl_3 (1 mark)



(Only 3 good positions will be taken into account; no partial marks)

Predict whether an aqueous solution of each of the following is acidic, basic or neutral: (4 mark)

		acid	neutral	basic
i.	LiNO_3	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
ii.	$\text{NH}_4\text{CH}_3\text{COO}$	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
iii.	N_2H_4	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
iv.	$\text{KC}_6\text{H}_5\text{O}$	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

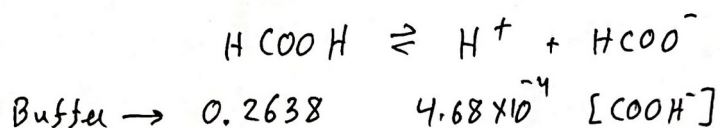
Question 7

- a. A buffer solution is made from the mixture of 225 mL of 0.850 M formic acid (HCOOH) with 0.500 L of a solution of sodium formate (NaCOOH). If the pH of this buffer is 3.33, calculate the sodium formate concentration in this mixture. (4 marks)

$$[\text{HCOOH}] = \frac{0.850 \text{ M} \times 0.225 \text{ L}}{(0.225 + 0.500) \text{ L}} = 0.2638 \text{ M}$$

$$[\text{H}^+] = 10^{-3.33}$$

$$[\text{H}^+] = 4.68 \times 10^{-4} \text{ M}$$



$$1.80 \times 10^{-4} = \frac{[\text{H}^+][\text{COOH}^-]}{[\text{HCOOH}]} = \frac{(4.68 \times 10^{-4})[\text{COOH}^-]}{0.2638} \rightarrow [\text{COOH}^-] = 0.102 \text{ M}$$

answer: _____ 0.102 M _____

- b. You want to make a buffer by adding NaOH to a weak acid. Which of the following weak acid is most suitable for preparing a buffer solution with pH = 4? (Circle one, use data sheet) (1 mark)

i. Hydrocyanic acid

iii. Formic acid

ii. Hypochlorous acid

iv. Nitrous acid

- c. Which combination of equal volumes of chemicals **will not** make a buffer (circle one) (1 mark)

i. 0.25 M KF + 0.50 M HF

iii. 0.50 M HClO₄ + 0.25 M KClO₄

ii. 0.25 M KOH + 0.50 M HCN

iv. 0.50 M HClO + 0.25 M Ba(ClO)₂

- c. Which combination of equal volumes of chemicals **will make** a buffer (circle one) (1 mark)

i. 0.5 M HClO + 0.5 M HCl

iii. 0.5 M Ba(NO₂)₂ + 1.0 M HNO₂

ii. 0.5 M KOH + 0.5 M HCN

iv. 0.5 M KCN + 0.5 M KBr

Question 8

Calculate the pH of the buffer obtained from the reaction of 55.0 mL of 0.0470 mol/L HCl with 245 mL of 0.0264 mol/L CH_3NH_2 (methylamine, $K_b = 4.40 \times 10^{-4}$) (5 marks)

$$[\text{H}^+] = \frac{(55.0 \text{ mL})(0.0470 \text{ M})}{(55 + 245) \text{ mL}} = 8.62 \text{ mM}$$

$$[\text{B}] = \frac{(245 \text{ mL})(0.0264 \text{ M})}{300. \text{ mL}} = 21.56 \text{ mM}$$

Reaction	$\text{B} + \text{H}^+ \rightarrow \text{BH}^+$
I	21.56 8.62 -
R	-8.62 -8.62 +8.62
F	12.94 - 8.62 mM

equilibrium

	$\text{B} + \text{H}_2\text{O} \rightleftharpoons \text{BH}^+ + \text{OH}^-$	$K_b = 4.4 \times 10^{-4}$
I	12.94	8.62
C	-x	+x +x
E	12.94	8.62 x ← Buffer!

$$4.40 \times 10^{-4} = \frac{[\text{BH}^+][\text{OH}^-]}{[\text{B}]} = \frac{(8.62)(\text{OH}^-)}{12.94}$$

$$[\text{OH}^-] = 6.605 \times 10^{-4}$$

$$\text{pOH} = 3.180 \quad \Rightarrow \quad \text{pH} = 10.820.$$

answer: _____ 10.820 _____ (correct with 3 s.f. after the dot)