



THOMPSON RIVERS
UNIVERSITY
OPEN LEARNING

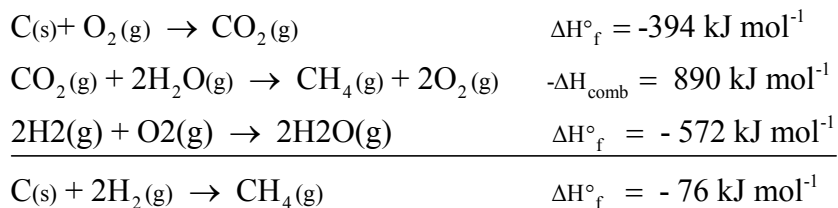
THOMPSON RIVERS UNIVERSITY,
OPEN LEARNING
ANSWER KEY

PRACTICE EXAMINATION

CHEM 1523 • PRINCIPLES OF CHEMISTRY

(3 marks)

1. a.



(9 marks)

b. i. $\Delta S^\circ = (S^\circ \text{KCl}) + 2(S^\circ \text{O}_2) - (S^\circ \text{KClO}_4)$

$$= 342 \text{ J K}^{-1} \text{ mol}^{-1}$$

ii. $\Delta H^\circ = (\Delta H^\circ \text{KCl}) - (\Delta H^\circ \text{KClO}_4) = -5 \text{ kJ mol}^{-1}$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -107 \text{ kJ}$$

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

$$K = 5.44 \times 10^{18}$$

iii. Yes; by inspection, entropy increases since the reaction goes from 1 mole of reactants to 3 moles of products, which agrees with ΔS° being positive ($342 \text{ J K}^{-1} \text{ mol}^{-1}$).

iv. ΔH° is negative and ΔS° is positive, so the reaction is spontaneous at all temperatures since ΔG° is negative at all temperatures.

$$K = [\text{O}_2]^2$$

(5 marks)

c.

$$\Delta E = q + w$$

$$q = -850 \text{ J}$$

$$w = -P_{\text{ext}} \Delta V$$

$$= -(1.7 \text{ atm})(3.3 \text{ L} - 6.6 \text{ L})(101 \text{ J L}^{-1} \text{ atm}^{-1})$$

$$= 5.7 \times 10^2 \text{ J}$$

The sign for w is positive since the surroundings do work on the system.

$$\Delta E = q + w$$

$$= -850 \text{ J} + 5.7 \times 10^2 \text{ J}$$

$$= -280 \text{ J}$$

(2 marks)

d.

i. false – The spontaneity will also depend on the change in the entropy.

ii. false – The free energy change for an exothermic reaction can be positive or negative depending on the change in entropy.

iii. true

iv. true

(5 marks) 2. a.

$$k = \frac{0.693}{5760} = 1.2 \times 10^{-4} \text{ yr}^{-1}$$

$$\ln(15.3/14.0) = kt$$

$$t = 740 \text{ years}$$

Thus, the cloth did not date from Biblical times (approximately 2000 years ago).

- (6 marks) b. When [A] is constant at 0.040 M and [B] increases by a factor of 1.5 from 0.040 to 0.060 M, the rate increases of 0.8×10^{-5} to $1.8 \times 10^{-5} \text{ M s}^{-1}$, which is an increase of 2.25 or $(1.5)^2$. Thus, the rate is second order: $[\text{B}]^2$.

$$k = \frac{1.8 \times 10^{-5} \text{ M s}^{-1}}{(0.060 \text{ M})^2} = 0.0050 \text{ M}^{-1} \text{ s}^{-1}$$

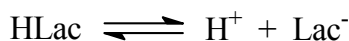
- (2 marks) c. $k = (1.8 \times 10^7 \text{ M s}^{-1}) (2 \times 10^{-8} \text{ M})^2$
 $= 6 \times 10^{-9} \text{ M s}^{-1}$

- (2 marks) d. $\text{rate} = k [\text{A}]^2$, which is second order.

- (8 marks) 3. a. i. 0 mL NaOH and 50 mL 0.100 M lactic acid

$$[\text{H}^+] = \sqrt{K_a [\text{acid}]}$$

Or, from the equilibrium



$$K_a = \frac{x^2}{(0.100 - x)} = 1.4 \times 10^{-4}$$

$$x = [\text{H}^+] = 3.7 \times 10^{-3}$$

$$\text{pH} = 2.43$$

- ii. 10 mL NaOH: this is an acid buffer composed of lactic acid and sodium lactate

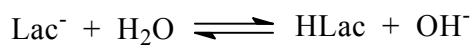
$$\begin{aligned} \text{pH} &= \text{p}K_a + \log \frac{[\text{salt}]}{[\text{acid}]} \\ &= 3.86 + \log \frac{(0.001)}{(0.004)} = 3.26 \end{aligned}$$

- iii. 25 mL NaOH: this is the mid-equivalence point

$$\text{pH} = \text{p}K_a = 3.86$$

- iv. 50 mL NaOH: this is the equivalence point. It is the salt of a weak acid–strong base, so it is basic.

$$K_b = K_w/K_a = 7.1 \times 10^{-11}$$



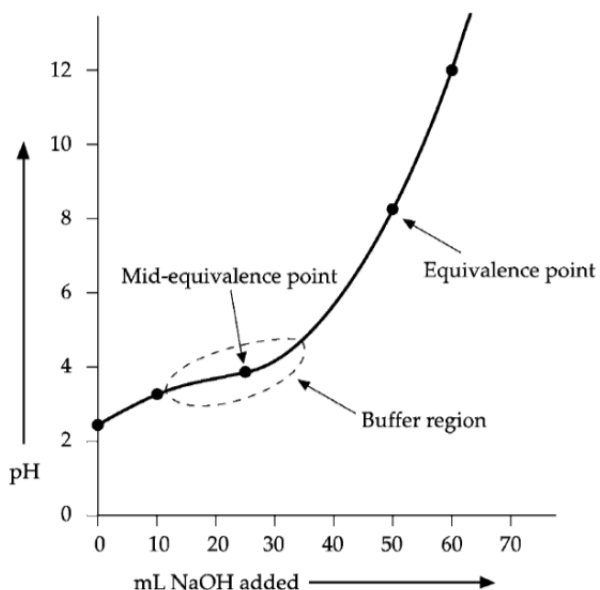
$$K_b = \frac{x^2}{(0.050 - x)} = 7.1 \times 10^{-11}$$

$$x = 1.9 \times 10^{-6} = [\text{OH}^-]$$

$$\text{pOH} = 5.72 \quad \text{pH} = 8.28$$

- v. 60 mL NaOH means 10 mL of 0.10 M NaOH in 110 mL of solution, which is 0.0091 M.

$$\text{pOH} = 2.04 \quad \text{pH} = 11.96$$



(5 marks) b. This is an acid solution, so use

$$\text{pH} = \text{p}K_{\text{a}} + \log \frac{[\text{salt}]}{[\text{acid}]}$$

$$K_{\text{a}} = 1.8 \times 10^{-5} \quad \text{p}K_{\text{a}} = 4.74$$

$$\frac{[\text{salt}]}{[\text{acid}]} = \frac{5.75}{1.00}$$

Thus, for every mole of acid we need 5.62 mol salt.

acid: 1.0 L of 0.10 M = 0.10 mol

salt: $5.75 \times 0.10 \text{ mol} = 0.575 \text{ mol}$

molar mass: 98 g mol^{-1}

mass: $0.575 \text{ mol} \times 98 \text{ g mol}^{-1} = 56 \text{ g}$

(2 marks) c. This is a salt of a weak acid–strong base, so the solution is basic.

$$K_{\text{b}} = K_{\text{w}}/K_{\text{a}} = 5.65 \times 10^{-11}$$

Mol KFa = 0.0714 (Fa = formate)

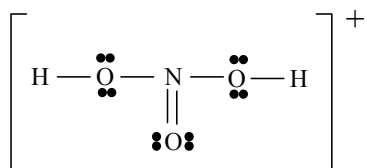
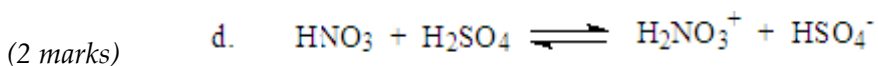
[KF a] = 0.0714 mol / 0.025 L = 2.8 M

	$\text{Fa}^- + \text{H}_2\text{O} \rightleftharpoons \text{HF a} + \text{OH}^-$		
Start	2.84	0	0
Equilibrium	$2.84 - x$	x	x

$$\frac{x^2}{2.84 - x} = K_{\text{b}} = 5.65 \times 10^{-11}$$

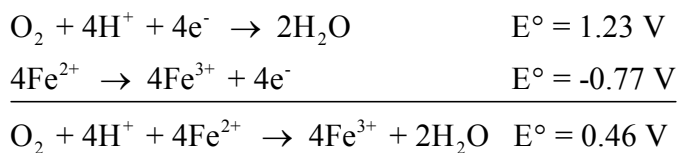
$$x = 1.26 \times 10^{-5} = [\text{OH}^-]$$

$$\text{pOH} = 4.90 \quad \text{pH} = 9.10$$



(2 marks) e. $[\text{H}^+] = 4.0 \times 10^{-8} \quad \text{pH} = 7.40$

(9 marks) 4. a.



$$\Delta G^\circ = -nFE^\circ = -1.78 \times 10^5 \text{ J}$$

$$\ln K = \frac{\Delta G^\circ}{RT} = 71.6$$

$$K = 1.3 \times 10^{31}$$

(2 marks) b. $E = E^\circ - \left(\frac{0.0590}{2} \right) \log \left(\frac{1}{[\text{Cu}^{2+}]} \right)$
 $= 0.36 \text{ V}$

(4 marks) c. $\text{mol Cu} = 0.00158 \text{ mol}$

$$\text{charge} = 0.00158 \text{ mol} \times 2\text{F/mol} \times 96,500 \text{ C/F} = 304 \text{ C}$$

$$\text{time} = \frac{\text{charge}}{\text{current}} = \frac{304 \text{ C}}{3.50 \text{ amp}} = 86.8 \text{ s}$$

(4 marks) d. i. Mg and Al

ii. Cr and Zn

(5 marks) 5. a.

$$K_p = 27.8$$

$$= K_c (RT)^{\Delta n} \quad \Delta n = -1$$

$$K_c = 6.80 \times 10^2$$

(2 marks)

b. $K_{sp} = 6.0 \times 10^{-36} = [\text{Cu}^{2+}][\text{S}^{2-}] = (0.50)[\text{S}^{2-}]$

$$[\text{S}^{2-}] = 1.2 \times 10^{-35} \text{ M}$$

(2 marks)

c. $K_{sp} = 6.0 \times 10^{-36} = [\text{Cu}^{2+}][\text{S}^{2-}] = x^2$

$$x = 2.44 \times 10^{-18} \text{ mol L}^{-1} = 2.3 \times 10^{-16} \text{ g L}^{-1}$$

(2 marks)

d.

$$K_p = \frac{1.0 \text{ atm}^2}{0.0040 \text{ atm}} = 2.5 \times 10^2$$

Thus, the system is not in equilibrium and consequently the equilibrium will move to the left to decrease $[\text{NO}_2]$ and increase $[\text{N}_2\text{O}_4]$.

(2 marks)

e. i. Right

ii. No change

iii. Left

iv. No change

(3 marks) 6. a.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \quad \text{and} \quad V_1 = V_2$$

$$\frac{10.0 \text{ atm}}{298 \text{ K}} = \frac{P_2}{1378 \text{ K}}$$

$$P_2 = 46.1 \text{ atm}$$

(5 marks) b. 23.9 L (HCl is the limiting reagent)

(P_{dry} of CO_2 at 25°C is $1.05 - 0.03 = 1.02 \text{ atm.}$)

(4 marks) c. 1.84 g L^{-1}

(3 marks) d. $\frac{\text{rate O}_2}{\text{rate O}_3} = 1.23$