13 [redacted]

General Chem. 102
Second Exam

Time: 60 min.
Date: 8/5/2012

Name:[redacted] Reg. No.: [redacted]

Instructor: 8:00 - 9:00 د.عماد الصانع Seat No.: ……………..

* * *

1 atm=760 mmHg , K=°C + 273 , R=8.314 J/mol.K=0.08206 L.atm/mol. K

$$\ln\frac{k_1}{k_2}=\frac{E_a}{R}\left(\frac{1}{T_2}-\frac{1}{T_1}\right), K_p=K_c\ (RT)^{\Delta n}\ ,\ pH = pK_a + \log\ [base]/[acid]$$

$K_W=1.0\times10^{-14}$

* * *

ANSWER SHEET

1.	a	b	c	d	[✓ e]	9.	a	[✓ b]	c	d	e
2.	a	[✓ b]	~~c~~	d	e	10.	a	b	c	~~d~~	[✓ e]
3.	a	[✓ b]	c	d	e	11.	[✓ a]	b	c	d	e
4.	[✓ a]	b	c	d	e	12.	a	b	[✓ c]	d	e
5.	a	b	c	[✓ d]	e	13.	a	[✓ b]	c	d	e
6.	[✓ a]	b	c	d	e	14.	a	b	c	[✓ d]	e
7.	a	b	[✓ c]	d	e	15.	[✓ a]	b	c	d	e
8.	a	b	c	[✓ d]	e ✓	16.	a	b	[✓ c]	d	e

Good Luck

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Circle the *correct* answer for each of the following questions and put (X) on the *corresponding choice* on the *front page*:

1. Given that E_a for a certain reaction is 65 kJ/mol,and the rate constant is $2.5x10^{-3}$ s^{-1} at 25.0 °C,what is the rate constant(in s^{-1}) at 37.0 °C?

a) $9.4x10^{-3}$ b) $5.9x10^{-3}$ c) $2.5x10^{-3}$ d) $8.1x10^{-3}$ [✓ e)] $6.9x10^{-3}$

6.9 x 10

$$\ln \frac{k_2}{k_1} = \frac{Ea}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right) \qquad \frac{k_2}{} = 2.7609$$

$$\ln \frac{k_2}{2.5\times10^{-3}} = \frac{65\times10^3}{8.314}\left(\frac{12}{310 * 298}\right)$$

2. Which of the following statements is correct?

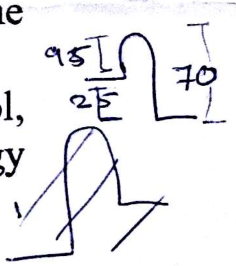
a) For an endothermic reaction, the activation energy of the reverse reaction is always greater than the activation energy of the forward reaction. x

[✓ b)] The activation energy of a reaction is negative if the reaction is exothermic.

c) The activation energy of a reaction is always positive whether the reaction is endothermic or exothermic.

d) The activation energy of a reaction depends on the temperature of that reaction.

e) If the activation energy of the forward reaction is 95 kJ/mol, and ΔH of the reaction is 25 kJ/mol, then the activation energy of the reverse reaction is – 70 kJ/mol.



Q 3. The proposed mechanism for the reaction

$$NO_2 + CO \rightarrow NO + CO_2$$

is:

$NO_2 + NO_2 \rightarrow NO_3 + NO$ slow rate = k

$NO_3 + CO \rightarrow NO_2 + CO_2$ fast

Which of the following statements is correct?

the rate law = k[NO_2][CO]

a) The rate law is : rate = k[NO_2][CO] ??

[✓ b)] The rate law is : rate = k$[NO_2]^2$

c) The rate law is : rate = k[NO_3][CO]

d) The rate law is : rate = k$[NO_2]^x[CO]^y$

e) NO_3 is a catalyst

4. For the reaction $A_2 + 2B \rightleftarrows 2AB$, $K_c = 1.44$
Calculate K_c for the reaction:

$$AB \rightleftarrows B + \frac{1}{2} A_2$$

$K_c = ((1.44)^{-1})^{1/2}$

0.8333

[✓ a) 0.833] b) 0.344 c) 0.640 d) 1.00 e) 0.429

✱ 5. For the reaction system

$$CaCl_{2(s)} + 2H_2O_{(g)} \rightleftarrows CaCl_2.2H_2O_{(s)}$$

The equilibrium constant expression; K_c , is:

$K_c = \frac{[CaCl_2 \cdot 2H_2O]}{[\cancel{CaCl_2}][H_2O]}$

a) $K_c = \frac{[CaCl_2.2H_2O]}{[CaCl_2][H_2O]^2}$ b) $K_c = \frac{1}{2[H_2O]}$ c) $K_c = [H_2O]^2$

[✓ d) $K_c = \frac{1}{[H_2O]^2}$] e) $K_c = \frac{[CaCl_2.2H_2O]}{[H_2O]^2}$

6. For the reaction:

$$4NO_{2(g)} \rightleftarrows 2N_2O_{(g)} + 3O_{2(g)}$$

$K_c = 9.7 \times 10^{-4}$ at 25 °C, calculate K_p?

[✓ a) 2.4×10^{-2}] b) 8.8×10^{-6} c) 1.9×10^{-3} d) 4.1×10^{-2} e) 1.4×10^{-4}

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

$K_p = 9.7 \times 10^{-4} (8.314 * (25+273))^1$

$K_p = 2.403$

0.38

$0.4 = \frac{x^2}{(0.\cancel{8} - x)^2}$

7. The equilibrium reaction

$$NO_{(g)} + CO_{2(g)} \rightleftharpoons NO_{2(g)} + CO_{(g)}$$

0.04 0.04 0 0

$-x$ $-x$ $+x$ $+x$

[O.

has $K_c = 0.0400$ at 25 °C. If 0.800 mol $NO_{(g)}$ and 0.800 mol $CO_{2(g)}$ are introduced into an empty 2.00 L flask at this temperature. Determine the molar equilibrium concentration of $NO_{(g)}$?

[NO]

K

$x = 0.126$

a) 0.0400 b) 0.167 [✓ c) 0.333] d) 0.0833 e) 0.250

$K = \frac{([NO_2][CO]}{}$

$0.04 = \frac{[x^2}{(0.4 - x)^2}$

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

$0.632 = \frac{x}{0.4 - x}$

0.08

0.2

$\cancel{0.253} - \cancel{0.632}x =$

$x = 0.155$

$0.2 \times 0.4 - 0.2x = x$

$2x = 0.08$

$x = 0.0666$

8. For the following reaction, $K_c = 7.5$ at 40 °C

$$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)} + \text{heat}$$

Which of the following statements is correct?

a) If 2.0 moles of $NO_{2(g)}$ and 1.2 moles of $N_2O_{4(g)}$ were mixed in a 5.0 L container then the mixture is at equilibrium.

b) Increasing the temperature will not affect the value of K_c. ×

c) Increasing the pressure by decreasing the volume will increase the amount of $NO_{2(g)}$ ×

[✓ d) Adding a catalyst will increase the amount of $N_2O_{4(g)}$.] ✓

e) Increasing the temperature will decrease the value of K_c

9. Calculate the pH of 0.40 M aqueous solution of HOCl ($K_a = 3.0 \times 10^{-8}$)

a) 5.00 [✓ b) 3.96] c) 4.77 d) 3.81 e) 7.00

$[H^+] = \sqrt{K_a \times [HOCl]}$

$= 1.095 \times 10^{-4}$

$pH = 3.96$

$K_b = [OH^-] = \sqrt{K_b \times [x^{-2}]}$

10. Given for the diprotic acid H_2X, $K_{a1} = 2.1 \times 10^{-6}$, $K_{a2} = 4.9 \times 10^{-12}$ Calculate the concentration of X^{-2} in 0.10 M aqueous solution of H_2X.

$H_2X + H_2O \rightleftharpoons X^{2-} + H$

$K_a = K_{a1} \times K_{a2}$

a) 4.9×10^{-11} b) 2.1×10^{-6} c) 1.8×10^{-10} d) 4.9×10^{-12} [✓ e) 2.8×10^{-9}]

$K_a = \frac{[H^+][x^{-2}]}{[H_2X]}$

$K_a = \frac{[H^+][X^{-2}]}{[H_2X]}$

1.01×10^{-9}

4.83×10^{-4}

11. Given: $K_a(CH_3COOH) = 1.8\times10^{-5}$, $K_a(HCOOH) = 1.7\times10^{-4}$ ↑ → ↑
$K_a(HNO_2) = 4.5\times10^{-4}$, $K_a(HF) = 7.1\times10^{-4}$

Which of the following is the correct order of base strength in aqueous solution?

$HF > HNO_2 > HCOOH > CH_3$
acidity

$F^- < NO_2^- < HCOO^- < CH_3CO$

[✓ a)] $CH_3COO^- > HCOO^- > NO_2^- > F^-$
b) $HCOO^- > CH_3COO^- > NO_2^- > F^-$
c) $CH_3COO^- > F^- > NO_2^- > HCOO^-$
d) $CH_3COO^- > NO_2^- > HCOO^- > F^-$
e) $F^- > NO_2^- > HCOO^- > CH_3COO^-$

12. Consider acid strength in aqueous solution, which of the following orders of acid strength is correct?

a) $H_2O > H_2S$
b) $HClO_3 > HClO_4$ ✗
[✓ c)] $H_2SO_3 > H_2SeO_3$
d) $H_3PO_3 > H_3PO_4$ ✗
e) $H_3PO_4 > HClO_4$ ✗

Cl, Br, I

13. Calculate the % ionization of NH_3 in 0.020 M aqueous NH_3 solution, $K_b(NH_3) = 1.8\times10^{-5}$

$$\% = \frac{[\text{ion}]}{[\text{base}]}$$

a) 5.3
[✓ b)] 3.0
c) 7.5
d) 1.3
e) 50.

$$[\ ] = \sqrt{1.8\times10^{-5}\times0.02}$$

$$\boxed{6\times10^{-4}}$$

14. Calculate the pH of 0.20 M $NaNO_2$ aqueous solution $K_a(HNO_2) = 7.1\times10^{-4}$

NO_2

$$[\ ] = \sqrt{Ka*[HNO_2]}$$

a) 8.52
b) 7.00
c) 8.72
[✓ d)] 8.22
e) 9.03

$$[OH^-] = \sqrt{K_b*[NO_2^-]}$$
$$= \sqrt{10^{-9}\times0.2}$$

1.678
~~1.414~~ $\times10^{-6}$

pOH = ~~4.849~~

HCOOH ⇌ ... $K_a = \frac{[H ...]}{[HCOOH]}$

4.08

15. Calculate the pH of a buffer that contains 0.40 M HCOOH and 0.82 M HCOONa. K_a (HCOOH) = 1.7×10^{-4}

[✓ a) 4.08] b) 4.37 c) 3.47 d) 3.77 e) 3.17

$PH_2 = 4.44$

n CH_3COOH = 0.8

n base = 0.6 − 0.2 = 0.4

$[H_3O^+] = 3.6 \times 10^{-5}$

16. Calculate the **pH change** when 0.20 mol HCl are added to 1.00 L buffer solution that contains 0.60 mol CH_3COOH and 0.60 mol CH_3COONa. Assume no volume change. K_a (CH_3COOH) = 1.8×10^{-5}

$PH_1 = 2.48$

a) 4.74 b) 0.30 [✓ c) -0.30] d) 0.15 e) -0.15

4.74

$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COOH$

0.6 0 0

0.6 +x +x

$1.8 \times 10^{-5} = \frac{x^2}{0.6 - x}$

$\boxed{x = 3.286 \times 10^{-3}}$

Bonus

$\Delta PH = PH_2 - PH_1 - 4.44$

17. Consider the equilibrium reaction:

$$CS_{2(g)} + 3Cl_{2(g)} \rightleftharpoons S_2Cl_{2(g)} + CCl_{4(g)}$$

0.5 1.5 0.5

3 → 1

1.5

When 1.00 mol of CS_2 and 3.00 mol of Cl_2 are placed in a 2.00 L container and allowed to react. At equilibrium, the mixture was found to contain 0.360 mol of CCl_4. Calculate the equilibrium constant K_c?

$\boxed{0.24}$

Answer:(~~0.24~~)

0.114

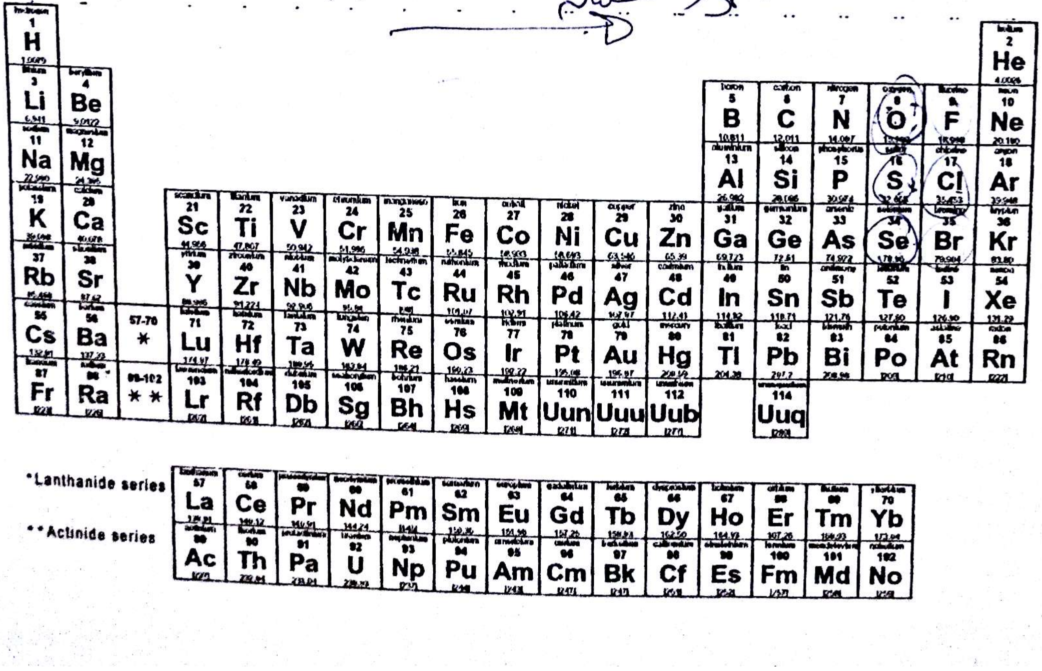
$$K_c = \frac{[S_2Cl_2][CCl_4]}{[CS_2][Cl_2]^3}$$

0.5 0.36

0.48

0.5 × 1.5 → 1

1.5 → x



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13

General Chem. 102
Second Exam

Time: 65 min.
Date: 30/4/2013

Name: [redacted]   Reg. No.: [redacted]
Instructor: كريم ملك قادري   Seat No.: 7

* * *

atm=760 mmHg ; K=°C + 273.2; R=8.314 J/mol.K= 0.08206 L.atm/mol. K;
pH = pK_a + log [base]/[acid]; K_w=$1.0x10^{-14}$; K_p =K_c $(RT)^{\Delta ng}$;
$\Delta G^o = \Delta H^o - T\Delta S^o$, $\Delta G = \Delta G^o + RT \ln Q$.

* * *

ANSWER SHEET

1. a b [✓ c] d e
2. a [✓ b] c d [✓ e] ✓
3. a b c d [✓ e]
4. a b [✓ c] d e
5. [✓ a] b c d e
6. a b c [✓ d] e
7. a [✓ b] c d e
8. a b [✓ c] d e
9. a b c d [✓ e]
10. a b [✓ c] [✓ d] e
11. [✓ a] b c d e
12. a b [✓ c] d e
13. a [✓ b] c d e
14. a [✓ b] [✓ c] d e ✓
15. a b c [✓ d] [✓ e] ✓
16. [✓ a] b c d e
17. a b c d [✓ e]

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Find the answer for each of the following questions and put (X) on the ***corresponding choice on the front page:***

1. For the equilibrium reaction:

$$2H_2O_{(l)} + O_{2(g)} \leftrightarrows 2H_2O_{2(aq)}$$

$K_c = \frac{[H_2O]^2}{[O_2]}$

The correct equilibrium constant expression is:

a) $K = [H_2O_2]^2/[O_2]\,[\cancel{H_2O}]^2$

~~b)~~ $K = [H_2O_2]^2\,[O_2]\,[H_2O]$

[✓ c) $K = [H_2O_2]^2/[O_2]$]

d) $K = [H_2O_2]/[O_2]\,[\cancel{H_2O}]$

e) $K = 1/[\cancel{O_2}]$

$\frac{1}{5}$

2. Consider the equilibrium reaction:

$$SO_{2(g)} + NO_{2(g)} \leftrightarrows SO_{3(g)} + NO_{(g)},\ K_c = 4.00 \text{ at a given T.}$$

0.2 0.2 0.2 0.2

If 1.00 mol of each of $SO_{2(g)}$, $NO_{2(g)}$, $SO_{3(g)}$ and $NO_{(g)}$ are introduced into an empty 5.00 L flask at the same temperature, calculate the ~~molar~~ concentration of $SO_{3(g)}$ at equilibrium?

$K_c = \frac{[SO_3][NO]}{[NO_2][SO_2]}$

a) 0.600 [✓ b) 0.267] c) 0.133 d) 0.533 e) 0.200 ✓

$\cancel{\frac{0.2}{0.2+0.2}}$

$\sqrt{4} = \sqrt{\frac{(0.2+x)^2}{(0.2-x)^2}}$

$0.4 = 2x = 0.2 + x$

$0.2 - 3x$

$0.2 = 3x$

3. Consider the equilibrium reaction: 3

$$2AB_{(g)} + \text{heat} \leftrightarrows A_{2(g)} + 2B_{(g)},\quad \Delta H = +\text{ve}$$

$\longleftarrow$

Which of the following statements is correct?

a) Increasing the pressure of the reaction by the addition of an inert gas will shift the equilibrium to left (same volume).
b) Adding a catalyst will increase the amount of A_2 at the end of the reaction. X
c) Changing the temperature of the reaction has no effect on the equilibrium. X
d) Increasing the temperature of the reaction will cause the equilibrium to shift to the left (in reverse direction). X
e) Increasing the temperature of the reaction will cause the equilibrium to shift to the right(in forward direction). ✓

4. For the equilibrium reaction: $2 - 3 = -1$

$2SO_{2(g)}$ + $O_{2(g)}$ ⇆ $2SO_{3(g)}$, $K_p = 5.60 \times 10^4$ atm^{-1} at 250. °C.

Calculate K_c (in L/mol) for the equilibrium at 250.°C.

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

$5.6 \times 10^4 \frac{1}{atm} = K_c (0.0820 * 523.$

$\frac{1}{atm} * \frac{L.atm}{mol.K} * K$

a) 1.84×10^6

b) 2.35×10^6

[✓ c) 2.40×10^6]

d) 3.32×10^6

e) 2.73×10^6

2.4

5. For the equilibrium reaction:

$$\xrightarrow{\hspace{4cm}}$$

$NH_4CO_2NH_{2(s)}$ ⇆ $2NH_{3(g)}$, + $CO_{2(g)}$, $K_c = 2.3 \times 10^{-6}$ at a given T.

$\frac{0.96}{2}$ $\frac{0.02}{2}$ $\frac{0.001}{2}$ $\frac{mol}{M}$

If 0.96 mol $NH_4CO_2NH_{2(s)}$, 0.020 mol $NH_{3(g)}$ and 0.0010 mol $CO_{2(g)}$ are introduced to a 2.0 L container at the same temperature, then at equilibrium:

$Q < K_c$

1.041×10^{-7}

✓ a) Amounts of NH_3 and CO_2 will be increased.

X b) Mass of $NH_4CO_2NH_2$ will increase.

X c) Amounts of NH_3 and CO_2 will be decreased.

X d) Masses of reactant and products will not change.

e) Concentration of $NH_4CO_2NH_2$ will be decreased. *

6. Calculate the pH of 0.0025 M $Ba(OH)_2$ solution. $Ba(OH)_2 \longrightarrow Ba^{+2} + 2OH^-$

a) 11.95

b) 12.11

c) 12.04

[✓ d) 11.70]

e) 11.85

7. Which of the following is not a conjugate acid-base pair?

a) H_3O^+, H_2O

X b) NH_4^+, NH_2^-

c) H_2SO_4, HSO_4^-

d) H_2S, HS^-

e) HNO_2, NO_2^-

8. Which of the following would give a basic aqueous solution?

Ba Cl₃ Cl H O H

a) $NaNO_3$ $+H_2O$ b) $Fe(NO_3)_3$ $+H_2O$ c) $NaNO_2$ $+H_2O$ d) $BaCl_2$ $+H_2O$ e) CO_2 $+H_2O$

$\rightarrow Na^+ + NO_3^-$

9. A 1.25M aqueous solution of a weak acid, HA, is 7.7% dissociated. Calculate the acid dissociation constant, K_a.

a) 1.1×10^{-2} b) 1.6×10^{-3} c) 3.3×10^{-4} d) 1.8×10^{-4} e) 8.0×10^{-3}

$Ka =$

$\frac{x}{1.25} = \frac{7.7}{100}$

$Ka = \frac{[H^+][A^-]}{[HA]}$

$x = 0.096$

$\overset{0.35}{NaH_2PO_4} \rightleftarrows Na^+ + \boxed{H_2PO_4^-}$

$\underset{0.45}{Na_2HPO_4} \rightarrow 2Na^+ + HPO_4^{-2}$

10. A buffer solution is prepared by dissolving 0.350 mol NaH_2PO_4 and 0.450 mol Na_2HPO_4 in 1.00 L aqueous solution. Calculate the pH change after the addition of 0.020 mol NaOH(s) to this buffer(Assume volume remains 1.00 L).
For H_3PO_4: $K_{a1} = 7.5 \times 10^{-3}$; $K_{a2} = 6.2 \times 10^{-8}$; $K_{a3} = 4.8 \times 10^{-13}$.

$\underset{0.35}{H_2PO_4^-} \rightleftarrows H^+ + H$

$HPO_4^- \rightleftarrows H^+ +$
1.47×10^{-4}

$HPO_4^- \rightleftarrows PO_4^{-3} +$
2.66×10^{-10}
$+$

a) - 0.02   b) +0.02   c) - 0.04   d) + 0.04   e) - 0.07

0.45
$+ 0.02$

$H^+ = 1.47 \times 10^{-4} + 2.656 \times 10^{-10}$ f - i
$= 1.47 \times 10^{-4}$ $=$

$4.8 \times 10^{-13} = \frac{}{0.45}$

$H^+ = 8.12 \times 10^{-4} + 0.02$

2.66×10^{-10}
$+ 0.02$

11. Calculate the pH of 0.20 M sodium nitrite, $NaNO_2$, solution. Ka for $HNO_2 = 4.0 \times 10^{-4}$.

0.43 ⇄
$NaNO_2 \rightleftarrows Na^+ + NO_2^-$

a) 8.35   b) 10.37   c) 11.42   d) 11.27   e) 10.52

$\underset{0.2}{NO_2^-} \overset{H_2O}{\rightleftarrows} HNO_2 +$

$Kb = 2.5 \times 10^{-11}$

12. Calculate the molar solubility of calcium fluoride in 0.30 M NaF solution. K_{sp} for $CaF_2 = 4.0 \times 10^{-11}$.

CaF_2 NaF

a) 1.0×10^{-9} M   b) 6.5×10^{-8} c) 4.4×10^{-10}

d) 2.9×10^{-8} e) 1.6×10^{-7}

$NaF \rightleftarrows \underset{0.3}{F^-} + \underset{0.3}{Na^+}$

$CaF_2 \rightleftarrows 2F^- + Ca^{+2}$

13. Which of the following processes or reactions is expected to have a +ve ΔS value ?

a) $CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(l)}$
b) $N_2O_{4(g)} \rightarrow 2NO_{2(g)}$ ✓
c) Freezing of water.
d) Condensation of vapor into liquid.
e) $3O_{2(g)} \rightarrow 2O_{3(g)}$

-396

14. Given the following data:
ΔH^o_f : $SO_{2(g)}$ = - 297 kJ/mol ; $SO_{3(g)}$ = - 396 kJ/mol.
S^o : $O_{2(g)}$ = 205 J/mol.K ; $SO_{2(g)}$ = 248 J/ mol.K and $SO_{3(g)}$ = 257 J/mol.K.
Calculate ΔG^o (in kJ/mol) for the following reaction at 25°C.

$$2\,SO_{3(g)} \rightarrow 2SO_{2(g)} + O_{2(g)}$$

ΔG

$\Delta H - T\Delta S$
$- T$
$+198 - T\ 187$

a) - 514 b) +142 c) -142 d) - 68.2 e) +514

$\Delta G^o = \Delta H - T\Delta S$
$= +198 - $
$298 * 187$

15. Given the following data for the reaction:

$$2NH_{3(g)} \rightarrow N_{2(g)} + 3H_{2(g)}$$

\+ \+

law

ΔH^o = +160 kJ/mol and ΔS^o = + 363 J/mol.K
Which of the following statements is correct?
a) The reaction is spontaneous at all temperatures.
b) The reaction is nonspontaneous at all temperatures.
c) The reaction is spontaneous at temperatures lower than 160 °C. ✓
d) The reaction is spontaneous at temperatures lower than 140 °C. ✓
e) The reaction is spontaneous at temperatures higher than 170 °C.

16. Given the following data for the reaction:

$$2H_2S_{(g)} + SO_{2(g)} \rightarrow 3\,S(s) + 2H_2O_{(g)}$$

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

$(\Delta H - T\Delta S) = -RT \ln K$

$\Delta H^\circ = -150.$ kJ/mol and $\Delta S^\circ = -186$ J/mol.K
K_p for the reaction at 298K is about:

a) 4×10^{16} ✓ b) 7×10^{14} c) 5×10^{15} d) 3×10^{17} e) 2×10^{18}

-38.17

17. Consider the reaction:

$$2NO_{2(g)} \rightarrow 2\,NO_{(g)} + O_{2(g)} \quad , \Delta G^\circ = +70 \text{ kJ/mol}$$

Which of the following statement is correct?

a) The equilibrium constant for the reaction is more than 1.00. ✗
b) Increasing the partial pressure of NO will increase the equilibrium constant for the reaction.
c) Increasing the partial pressure of NO will decrease the equilibrium constant for the reaction.
d) The reaction is spontaneous at all conditions of gas pressures and temperatures.
e) The reaction is non-spontaneous under standard conditions. ✓

8

General Chem. 102
Second Exam

Time: 65 min.
Date: 10/5/2014

Name: [redacted] Reg. No.: [redacted]
Instructor: ……………………………………… Seat No.: ……………

* * *

1 atm=760 mmHg ; K=°C + 273.2; R=8.314 J/mol.K=0.0821 L.atm/mol.K;
$pH = pK_a + \log [base]/[acid]$; $K_w = 1.0\times10^{-14}$; $K_p = K_c (RT)^{\Delta n}$;
$\Delta G^o = \Delta H^o - T\Delta S^o$; $\Delta G = \Delta G^o + RT \ln Q$; $\Delta G^o = - RT \ln K_p$

* * *

79.7

Answer Sheet

1. a b c d e
2. a b ~~c~~ [✓ d] e
3. a b c ~~d~~ e
4. ~~a~~ b c d e
5. a b c [✓ d] ~~e~~
6. a b [✓ c] d e
7. a b c [✓ d] e
8. a b c d [✓ e]
9. a b c d e

10. a [✓ b] c d e
11. a b ~~c~~ d e
12. a b c ~~d~~ e
13. a b c d e
14. a [✓ b] ~~c~~ d e
15. a b c d ~~e~~
16. a b c d e
17. ~~a~~ b [✓ c] d e
18. a b [✓ c] ~~d~~ e

1. Consider the equilibrium reactiton:

$$2\,NO_{(g)} + O_{2(g)} \rightleftharpoons 2NO_{2(g)};\; K_c = \left(\frac{1}{7.0 \times 10^{5}}\right)^{2} \text{ at } 500\text{ K.}$$

Calculate the value of K_c for the following equilibrium:

$$NO_{2(g)} \rightleftharpoons NO_{(g)} + \tfrac{1}{2}\,O_{2(g)}$$

a) 3.8×10^{-4} ~~b)~~ 1.2×10^{-3} [✓ c) 2.0×10^{-3}]

d) 4.3×10^{-5} e) 6.2×10^{-4}

2. Consider the following reaction

$$2NO_{(g)} + Br_{2(g)} \rightleftharpoons 2\,NOBr_{(g)};\; K_c = 0.0472 \text{ at } 992\text{ K.}$$

Calculate the value of K_p for same reaction at 992 K.

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

$\frac{K_c}{RT}$

a) 7.5×10^{-4} b) 1.2×10^{-4} c) 5.8×10^{-4}

~~d)~~ 4.6×10^{-4} e) 9.0×10^{-4}

103?8

3. Consider the equilibrium reaction:

طارد

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons \underline{2NH_{3(g)}}\uparrow;\; \Delta H = -24.7\text{ kJ/mol.}$$

Which of the following effects will increase the amount of NH_3 at equilibrium?

a) Increase the temperature.

b) Decrease the concentration of N_2.

~~c)~~ Add a catalyst.

d) Decrease the total volume of reaction mixture.

e) Add an inert gas, at same total volume.

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4. Consider the following equilibrium at 1320 K:

$$COCl_{2(g)} \rightleftharpoons CO_{(g)} + Cl_{2\,(g)}$$

When a sample of 0.600 moles of $COCl_{2(g)}$ is placed in a 1.00 L cantainer and the reaction is allowed to reach equilibrium. The equilibrium concentrations of CO was 0.059 M.

Calculate equilibrium constant K_c for the reactionis :   K

a) 6.4×10^{-3} b) 5.4×10^{-3} c) 9.0×10^{-3}

d) 3.7×10^{-3} e) 7.2×10^{-3}

$$K_c = \frac{[I_2][Br]}{[IBr]^2}$$

0.0625

5. Consider the following equilibrium:

$2IBr_{(g)} \rightleftharpoons I_{2(g)} + Br_{2(g)}$; $K_c = 0.0256$ at 100 °C.

If 1.00 mole of IBr is placed into a 4.00 L vessel at 100 °C and the reaction is allowed to reach equilibrium.
Calculate the molar concentration of Br_2 at equilibrium.

a) 0.076 b) 0.061 c) 0.024 [✓ d) 0.048] e) 0.030

6. Which one of the following would be a conjugate acid - base pair?

a) OH^- / H_3O^+ b) H_2SO_4/SO_4^{2-} [✓ c) NH_3/NH_2^-]

d) NH_3/ OH^- e) H_3PO_4/HPO_4^{2-}

$H_2O + H_2O \rightarrow H_3O^+ + OH^-$

$NH_3 \rightarrow H^+ + NH_2^-$

7. Calculate the molar concentration of H^+ in a 0.20 M aqueous solution of hydrazine. Hydrazine, N_2H_4, is a weak base, $K_b = 1.7 \times 10^{-6}$.

a) $1.1\text{x}10^{-11}$ b) $1.4\text{x}10^{-11}$ c) $2.4\text{x}10^{-11}$

[✓ d) $1.7\text{x}10^{-11}$] e) $1.9\text{x}10^{-11}$

$OH^- = \sqrt{0.2 \times 1.2}$

5.8×10^{-4}

8. A weak acid is 8.00 % ionized in 0.0200M aqueous solution of the acid at 25°C. Calculate pK_a for the acid.

$\frac{A^-}{HA}$

a) 4.24 b) 3.56 c) 3.38 d) 3.16 [✓ e) 3.86]

$\% = \frac{H^+}{0.02} \times 100$ $-\log Ka.$

$H^+ = 1.6 \times 10^{-3}$ $8 = \sqrt{K(0.02)}$ $Ka = 1.28 \times 10^{-4}$

$PH = pKa + \log \frac{0.0}{0.9}$

1.04

2.7

9. Calculate the pH of 0.40 M aqueous solution of the diprotic acid H_2A.
For H_2A: $K_{a1} = 2.6\text{x}10^{-5}$ and $K_{a2} = 4.8 \text{x} 10^{-12}$.

[✓ a) 2.49] b) 2.44 c) 2.82 d) 2.55 e) 2.64

$PH = -\log H^+$

$H^+ = \sqrt{Ka\,(m)} = 3.22 \times 10^{-3}$

1.3×10^{-6}

1.8×10^{-5}

P^H

$OH^- = 8.42 \times 10^{-3}$

~~2.426~~

10. Calculate the pH of 0.65 M aqueous solution of ammonium nitrate, NH_4NO_3. $K_b(NH_3) = 1.8 \times 10^{-5}$.

0.5×10^{-9}

a) 4.66 [✓ b) 4.72] c) 4.80 d) 4.93 e) 5.14

$OH^- = \sqrt{1.8 \times 10^{-5} * 0.65}$

$pOH = -\log OH$

$pOH = 2.42$

$pH = -\log H^+$

$H^+ + OH^- \rightarrow$

11. Which of the following aqueous buffer solutions has the highest buffer capacity?

a) 0.10 M NH_3 / 0.10 M NH_4Cl.
b) 0.10 M NH_3 / 0.50 M NH_4Cl.
c) 0.50 M NH_3 / 0.50 M NH_4Cl.
d) 0.50 M NH_3 / 0.10 M NH_4Cl.
e) 0.010 M NH_3 / 0.010 M NH_4Cl.

1000

12. Calculate the pH of a buffer prepared by mixing 500.0 mL of 0.20 M aqueous solution of HF and 500.0 mL of 0.40 M aqueous solution NaF. $K_a(HF) = 6.8 \times 10^{-4}$.

a) 8.43 b) 3.77 c) 2.87 d) 3.47 e) 2.57

$HF \rightarrow H^+ + F^-$

0.20

$NaF \rightarrow Na^+ + F^-$

$MV = MV$

$[\ ][\ ]$

$F\ [0.1]$

$[0.2]$

13. Calculate the change in **pH** when 0.03 mol HCl are added to 1.00 L buffer solution that contains 0.60 mol NH_3 and 0.70 mol NH_4Cl. Assume no volume change. $K_b(NH_3) = 1.8 \times 10^{-5}$.

[✓ a) Decrease by 0.04] b) Decrease by 0.08 c) Increase by 0.04

d) Increase by 0.04 e) No change in pH.

14. Which one of the following changes would have negative ΔS sign?

a) $H_2O_{(s)} \rightarrow H_2O_{(g)}$ +
b) Dissolving glucose in water.
c) $2CH_3OH_{(l)} + 3O_{2(g)} \rightarrow 2CO_{2(g)} + 4H_2O_{(l)}$ +
d) $CS_{2(l)} + 2H_2O_{(l)} \rightarrow CO_{2(g)} + 2H_2S_{(g)}$ +
e) $H_2O_{(l)}$ at 25°C → $H_2O_{(l)}$ at 75°C.

15. Given the following data:

	ΔH^o_f (kJ/mol)	S^o (J/mol.K)
$CH_3OH_{(l)}$	-259	127
$H_2O_{(l)}$	-286	70.0
$CO_{2(g)}$	-394	214
$O_{2(g)}$	---	205

ΔH
−3222736

Calculate ΔG° (in kJ/mol) for the following reaction at 25°C.

$$CH_3OH_{(l)} + \overset{1.5}{3/2O_{2(g)}} \rightarrow \overset{2}{2H_2O_{(l)}} + CO_{2(g)}$$

ΔS° = 675835
ΔS = [CO₂]
4.52

a) – 703   b) - 693   [✓ c) -713]   d) - 815   e) – 683

ΔS° = [H₂O]² [CO₂] − [O₂]^1.5 [CH₃OH]

ΔΔH:

spont (−)
ΔG = ΔH − TΔS
(+)
+

16. Consider the following reaction:

$$COCl_{2(g)} \rightarrow CO_{(g)} + Cl_{2(g)}$$

ΔH + +109
ΔS° = +137
109 − T137

ΔH° = +109 kJ/mol and ΔS° +137 J/mol.K.
Which of the following statements is correct?
a) The reaction is spontaneous at all temperatures.
b) The reaction is spontaneous at temperature higher than 550 °C.
c) The reaction is non-spontaneous at all temperatures.
d) The reaction is spontaneous at temperature between 100 -500 °C.
e) The reaction is spontaneous at temperature less than 100 °C.

109000 −
112751

26.56

~~0.08~~

$\Delta E = 265$

17. Consider the reaction:

$$SO_{2(g)} + H_{2(g)} \rightarrow H_2S_{(g)} + O_{2(g)}$$

$\Delta H^o = 278$ kJ/mol and $\Delta S^o = 31.9$ J/mol.K.
At 127.0 °C, K_p for the reaction is about:

a) 2×10^{-35}

b) 9×10^{-34}

[✓ c)] 4×10^{-33}

d) 7×10^{-32}

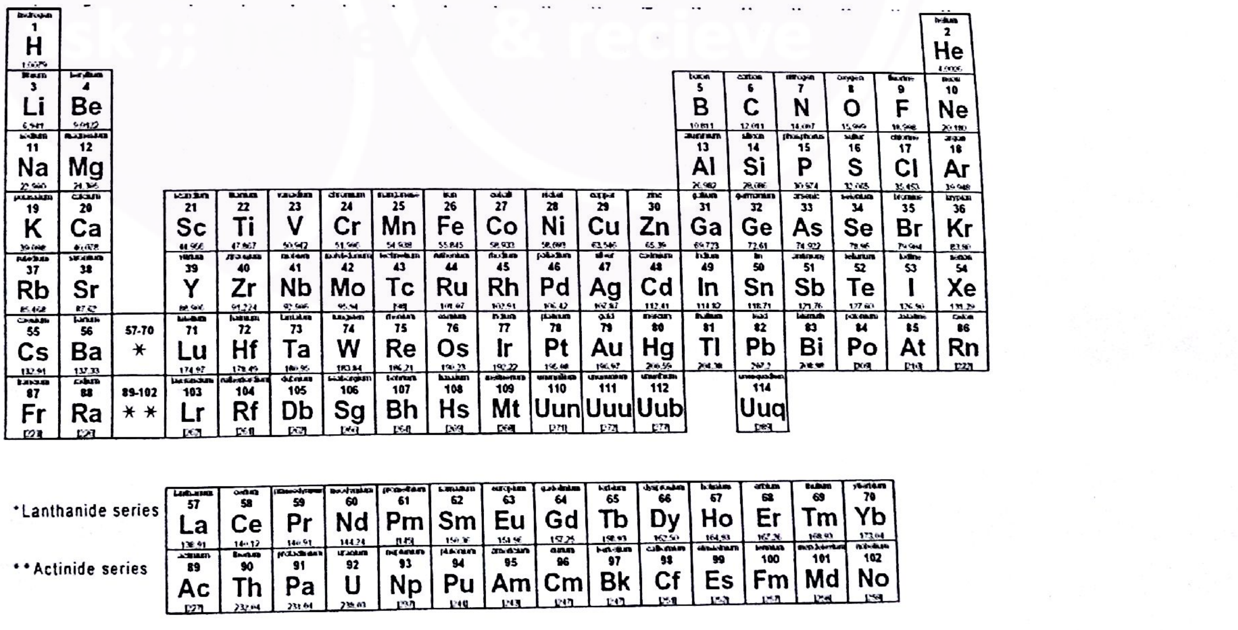
e) 1×10^{-36}

18. Consider the reaction:

Zero

$CO_{2(g)} + H_{2(g)} \rightarrow CO_{(g)} + H_2O_{(g)}$, $\Delta G^o = +41$ kJ/mol at 298 K.
Which of the following statements is true about the reaction?

a) The reaction is spontaneous under standard conditions.
b) The reaction is spontaneous under all partial pressures of reactants and products.
c) The reaction is non-spontaneous under all partial pressures of reactants and products.
d) The reaction could be spontaneous if Q_p (reaction quotient) is 10^{-10}.
e) Equilibrium constant for the reaction is greater than 1.00.



1 H																		2 He
3 Li	4 Be												5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg												13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca		21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr		39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57-70 *	71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-102 * *	103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun	111 Uuu	112 Uub		114 Uuq				

*Lanthanide series	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
**Actinide series	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

1

42

seat number:
42

15/17

The University of Jordan
Dept. Of Chem.

General Chem.102 **First Exam**
Date: 12/3/2016 Time: 60 Min.
Name: ....نور ماجد سمور............ Reg. No.:....0153452.............
Instructor Name: .... Section;........................شعبة ٢ : من الساعة ٩ ونص للـ ١١

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1 atm=760 mmHg , K=°C + 273 , R=8.314 J/mol.K=0.0821 L.atm/mol K

$$\ln\frac{P_1}{P_2} = \frac{\Delta H_{vap}}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right] \quad ; \pi = MRT \; ; \; \Delta T_f = k_f m \; ; \; \Delta T_b = k_b m$$

$$\frac{1}{[A]t} - \frac{1}{[A]o} = kt; \; \ln\frac{k1}{k2} = -\frac{E_a}{R}\left(\frac{1}{T1} - \frac{1}{T2}\right); \; [A]_t = [A]_o e^{-kt}; \; \boxed{\ln\frac{[A]_t}{[A]_o} = -kt}$$

---

1. [✓ **a**] **b** **c** **d** **e**

2. **a** **b** [✓ **c**] **d** **e**

3. [✓ **a**] **b** **c** **d** **e**

4. **a** [✓ **b**] **c** **d** [✓ **e**]

5. **a** [✓ **b**] **c** **d** **e**

6. **a** **b** **c** [✓ **d**] **e**

7. **a** **b** [✓ **c**] **d** **e**

8. [✓ **a**] **b** **c** **d** **e**

9. **a** **b** [✓ **c**] **d** **e**

10. **a** [✓ **b**] **c** **d** **e**

11. **a** **b** [✓ **c**] **d** [✓ **e**]

12. **a** **b** **c** [✓ **d**] **e**

13. **a** **b** **c** **d** [✓ **e**]

14. **a** [✓ **b**] **c** **d** **e**

15. **a** **b** **c** **d** [✓ **e**]

16. **a** **b** **c** [✓ **d**] **e**

17. **a** **b** **c** **d** [✓ **e**]

Circle the correct answer for each of the following questions and put (x) on the corresponding choice on the front page:

IMC ↑

Q1. Based on intermolecular interactions, which of the following should have the highest boiling point?

pb ↑.

[✓ a) C_2H_5OH]   b) CO_2 c) H_2S d) CH_3OH e) CH_4

Q2. What type of attractive forces is being overcome when liquid oxygen boils at 90 K?

O_2

a) ionic bonds .   b) dipole-dipole forces.   [✓ c) dispersion forces.]
d) covalent bonds.   e) hydrogen bonds.

Q3. A liquid boils when its

[✓ a) vapor pressure is equal to, or greater than, the external pressure pushing on it]
b) vapor pressure is exactly 1 atmosphere.
c) vapor pressure is lower than external pressure.
d) temperature is equal to 273 K (standard temperature).
e) temperature is greater than room temperature.

Q4. Consider the following pairs of liquids. Which pairs are miscible?
1. benzene, C_6H_6, and hexane, C_6H_{12}
2. water and methanol, CH_3OH
3. water and hexane

a) 2 only   b) 1, 2 only   c) 1 only   d) 1, 2, 3   [✓ e) 2, 3 only]

Q5. The vapor pressure of ethanol is 565 mmHg at 79.5°C. Its molar heat of vaporization is 39.5 kJ/mol. What is vapor pressure of ethanol, in mmHg, at 49.5°C?

a) 192   [✓ b) 161]   c) 565   d) 291   e) 760

$P_1 = 565$ mmHg $T_1 = 79.5C = \boxed{352.5\ K}$

$\Delta H_{vap} = 39.5 * 10^3$ $P_2 = ?$ $T_2 = 49.5C = \boxed{322.5}\ K$

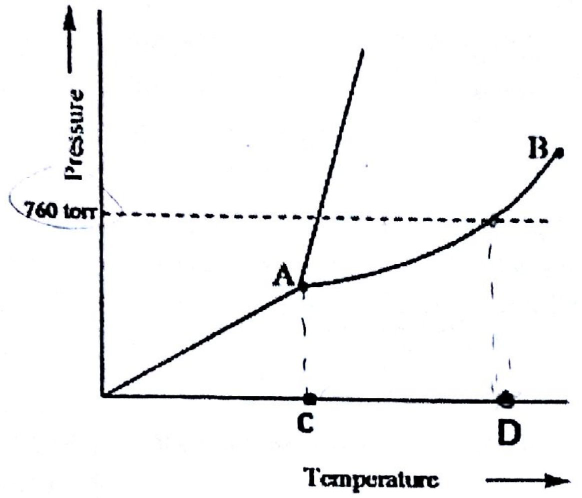
$$\ln\left(\frac{P_1}{P_2}\right) = \frac{\Delta H}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{565}{P_2}\right) = \frac{39.5 * 10^3}{8.314}\left(\frac{1}{322.5} - \frac{1}{352.5}\right)$$

$$e^{\ln\left(\frac{565}{P_2}\right)} = e^{1.253}$$

$$\frac{565}{P_2} = 3.5$$

Q6. Examine the following phase diagram and identify the feature represented by point D



a) Normal melting point
[✓ d) Normal boiling point]
b) Critical point
e) Sublimation point
c) Triple point

Q7. Calculate the molality of a solution that contains 51.2 g of $C_{10}H_8$ ($\mathcal{M}$= 128g/mol) in 500 mL of carbon tetrachloride. The density of CCl_4 is 1.60 g/mL.

a) 0.250 m
b) 0.750 m
[✓ c) 0.500 m]
d) 0.840 m
e) 1.69 m

mass = 51.2 Mm = 128

$m = \frac{n(\text{solute})}{\text{mass(solvent) kg}}$

$= \frac{0.4}{800 \times 10^{-3}}$

$= 0.5$

V = 500

d = 1.6

n = 0.4

$d = \frac{\text{mass}}{V}$

$1.6 = \frac{m}{500}$

$\boxed{m = 800g}$

Q8. If 4.27 grams of $C_{12}H_{22}O_{11}$($\mathcal{M}$= 342g/mol) are dissolved in 15.2 grams of water, what will be the boiling point of the resulting solution? (K_b for water = 0.512 °C/m)

[✓ a) 100.42 °C]
b) 101.64 °C
c) 99.626 °C
d) 100.73 °C
e) 101.42 °C

$C_{12}H_{22}O_{11}$

mass = 4.27

Mm = 342

solvent(water)

mass = 15.2

$K_b = 0.512$

$m = \frac{n}{\text{mass (kg)}}$

$\boxed{n = 0.012}$

$T_b = ?$

$\Delta T_b = K_b\ m$

$T_b - T_b^{\circ} = K_b\ m$

$T_b - 100 = 0.512 \times 0.8214$

$= \frac{0.012}{15.2 \times 10^{-3}}$

$\boxed{m = 0.8214}$

mass (solute) = 9.81 g   mass (solvent) = 90 g

Q9. A solution made by dissolving 9.81 g of a nonvolatile nonelectrolyte in 90.0 g of water boiled at 100.37 °C at 760 mm Hg. What is the approximate molar mass of the substance? (For water, $K_b = 0.51$ °C/m)

Mm = ?

a) 240 g/mol   b) 79 g/mol   [✓ c) 150 g/mol]
d) 61 g/mol   e) 34 g/mol

$\Delta T_b = K_b\, m$

$T_b - T_b^\circ = K_b\, m$

$100.37 - 100 = 0.51\, m$

$\boxed{m = 0.725}$

$m = \frac{n}{\text{mass}}$

$0.725 = \frac{n}{90 \times 10^{-3}}$

$n = \frac{\text{mass}}{Mm} \rightarrow 0.$

$n = 0.065$

$0.065 = \frac{9.81}{Mm}$

Q10. Calculate the molarity of a 4.666 m solution of a compound ($\mathcal{M}$ = 272.77 g/mol) which has a density of 1.1066 g/mL.

a) 4.966 M   [✓ b) 2.272 M]   c) 4.056 M   d) 4.216 M   e) 4.666 M

Mm = 272.77

d = 1.1066

$4.666\ m \longrightarrow M$

$\frac{4.666 \text{ mol (solute)}}{1 \text{ Kg (solvent)}} \longrightarrow \frac{4.666}{V(L)}$

$d = \frac{\text{mass}}{V} =$

mass (solution) = 1000 + $\cancel{\ }$

= 2272.7 g

$1.1066 = \frac{2272.7}{V}$

$V = 2053.8$

Q11. Colligative properties depend on

a) The chemical properties of the solute.
b) The chemical properties of the solvent
c) The number of particles dissolved.?
d) The masses of the individual ions.
[✓ e) The molar mass of the solute.] ?

Q12. State the van't Hoff factor (i) for a dilute aqueous solution of the strong electrolyte barium hydroxide, $Ba(OH)_2$

Ba^{+2} $+ 2OH^{-1}$

a) 0   b) 1   c) 2   [✓ d) 3]   e) 5

Q13. The rate constant for a given reaction is 0.134 $M^{-1}.s^{-1}$ at 27°C and 0.569 $M^{-1}.s^{-1}$ at 177 °C. Calculate the rate constant at 100 °C.

a) 0.731 $M^{-1}.s^{-1}$ b) 0.421 $M^{-1}.s^{-1}$ c) 0.212 $M^{-1}.s^{-1}$
d) 0.612 $M^{-1}.s^{-1}$ [✓ e) 0.313 $M^{-1}.s^{-1}$]

$K_1 = 0.134$ $K_2 = 0.569$

$T_1 = 27C\ \boxed{= 300}$ $T_2 = 177 = \boxed{450}$

$\ln\left(\frac{K_1}{K_2}\right) = -\frac{Ea}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$\ln\left(\frac{0.134}{0.569}\right) = -\frac{Ea}{8.314}\left(\frac{1}{300} - \frac{1}{450}\right)$

$-1.45 = +\frac{Ea}{8.314}($

$1.45 = 1.336 \times 10^{-4}\ Ea \rightarrow = 10853.29$

$K_1 = 0.134$ $T_1 = 27$

$K_2 = ?$ $T_2 = 100$

$Ea =$

$\ln\left(\frac{0.134}{K_2}\right) = -\frac{10853.29}{8.314}\left(\frac{1}{300} - \frac{1}{373}\right)$

$\cancel{\ln}\left(\frac{0.134}{K_2}\right) = -0.852$

e

$\frac{0.134}{K_2} = 0.4265$

Q$_{14}$. For the reaction $2NO + Cl_2 \rightarrow 2NOCl$ the following experimental data were obtained

run	[NO] M	[Cl_2] M	Initial rate M/hour
1	0.50	0.50	1.14
2	1.00	1.00	9.12
3	1.00	0.50	4.56

$2^x = 4$

$x = 2$

The rate law for the reaction is:

rate $= k\,\{No\}^2\,[Cl_2]^1$

$(0.5)^y = 0.5$

$y = 1$

a) rate = $k[Cl_2]$

[✓ b) rate = $k[NO]^2\,[Cl_2]$]

c) rate = $k[NO][Cl_2]$

d) rate = $k[NO]^2$

e) rate = $k[NO]^2\,[Cl_2]^2$

Q$_{15}$. The decomposition of dinitrogen pentoxide has a rate constant = 0.080 min^{-1}. If the initial concentration of N_2O_5 is 0.30 M, calculate the concentration after 2.6 minutes.

$K = 0.08$

a) 0.38 M b) 0.028 M c) 0.32 M d) 0.13 M [✓ e) 0.24 M]

First

$\{A_0\} = 0.3\,M$

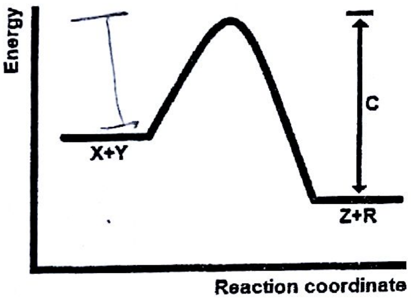
$\{A\} = ?$

$t = 2.6$

Q$_{16}$. Given the following potential energy diagram for the one-step reaction $X + Y \rightarrow Z + R$.

$\ln[A_t] - \ln[A_0] = -kt$

$\ln[A_t] - \ln(0.3) = -0.08 * 2.6$



$\ln\{A\} + 1.2 = -0.208$
$\phantom{\ln\{A\}} - 1.2 \quad\; - 1.2$

$\ln[A] = -1.408$

The arrow "c" represents :

a) enthalpy of the reaction in the reverse direction

b) enthalpy of the reaction in the forward direction

c) activation energy for the forward reaction

[✓ d) activation energy for the reverse reaction]

e) transition state

$\ln 55 - \ln[100] = +k * 65$

Ea. $+0.597 =$

$K = 9.797 \times 10^{-3}$

Q$_{17}$. A certain first order reaction is 45.0% complete in 65 seconds. Determine the half-life for this process

a) 5 s b) 23 s c) 20 s d) 10 s [✓ e) 75 s]

$\ln[\frac{A_0}{2}] - \ln[A_0] = -kt$

~~$\ln\{A_0\}$~~ $- \ln 2$ ~~$- \ln[A_0]$~~ $= -kt$

$t = \frac{\ln 2}{k}$

$= \frac{\ln 2}{}$