Lester B. Pearson School Board

Commission scolaire Lester-B.-Pearson

JUNE 2013

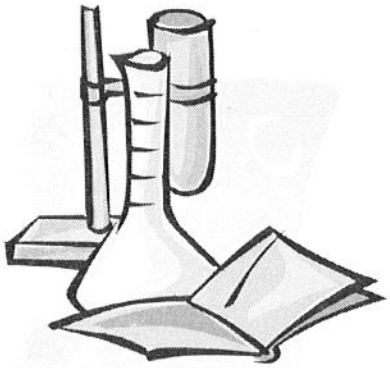
It's A

CHEMISTRY

Secondary 5

551-504

Theory Examination



Answer Booklet

Name: Darlene McRae Date: _____ Group: _____

Part A:	____ / 40
Part B:	____ / 60
Total:	____ /100

Time: 3 hours

BIM

Part A ***Multiple-Choice Questions***

Questions 1 to 10

Shade the letter that corresponds to your answer.

Each question is worth 4 marks.

Question 1 [A] [B] [C] [D]

Question 2 [A] [B] [C] [D]

Question 3 [A] [B] [C] [D]

Question 4 [A] [B] [C] [D]

Question 5 [A] [B] [C] [D]

Question 6 [A] [B] [C] [D]

Question 7 [A] [B] [C] [D]

Question 8 [A] [B] [C] [D]

Question 9 [A] [B] [C] [D]

Question 10 [A] [B] [C] [D]

Part A ***Multiple-Choice Questions***

Questions 1 to 10

Answer all questions in the ***Answer Booklet***.

Each question is worth four marks.

Question 1

Gases are used in a variety of areas of human activity. Here are a few examples:

1. In the field of aviation, inflating tires b think air! = 78% N_2 ✓ 21% O_2
2. Cooking on the barbeque d
3. Filling balloons used in meteorology a
4. Fighting blazes with fire extinguishers c

Associate each of these uses with one of the gases listed below.

a. Helium, He 3
b. Nitrogen, N_2 1
c. Carbon Dioxide, CO_2 4
d. Propane, C_3H_8 2

A) ~~1a~~, 2d, 3b and 4c

B) 1b, ~~2c~~, 3d and 4a

C) 1b, 2d, 3a and 4c

D) ~~1c~~, 2b, 3a and 4d

same V, T, P ! ∴ same # moles (n)

Question 2

Two bottles of gas with the same volume were filled under the same conditions of temperature and pressure. One contains oxygen, O_2, and the other nitrogen, N_2. Both bottles were opened at the same time.

(32 g/mol (28 g/mol

Which of the following statements is **TRUE**?

A) The bottle containing nitrogen empties more quickly because its molar mass is less than that of oxygen.

the greater the molar mass the slower the velocity = Graham's law

B) The bottle containing oxygen empties more quickly because its molar mass is greater than that of nitrogen.

C) The two bottles of gas empty at the same time because they contain the same number of molecules of gas. they do contain the same # n

D) The two bottles of gas empty at the same time because the two gases have the same kinetic energy. ✓

they do not have the same velocity or mass

same $E_K = \frac{1}{2}mv^2$ ↑m = ↓v at same T

Question 3

Two gas cylinders of the same volume are exposed to the same conditions of temperature and pressure. One contains propane gas, C_3H_8, and the other butane gas, C_4H_{10}.

Which of the statements below is **TRUE**? 44 g/1 mol 58 g/1 mol

A) Both cylinders contain the same mass of gas.

B) Both cylinders contain the same number of moles of gas. ✓

C) There are more molecules of propane than molecules of butane.

D) There are more molecules of butane than molecules of propane.

same V, T, P = same # n = same # particles

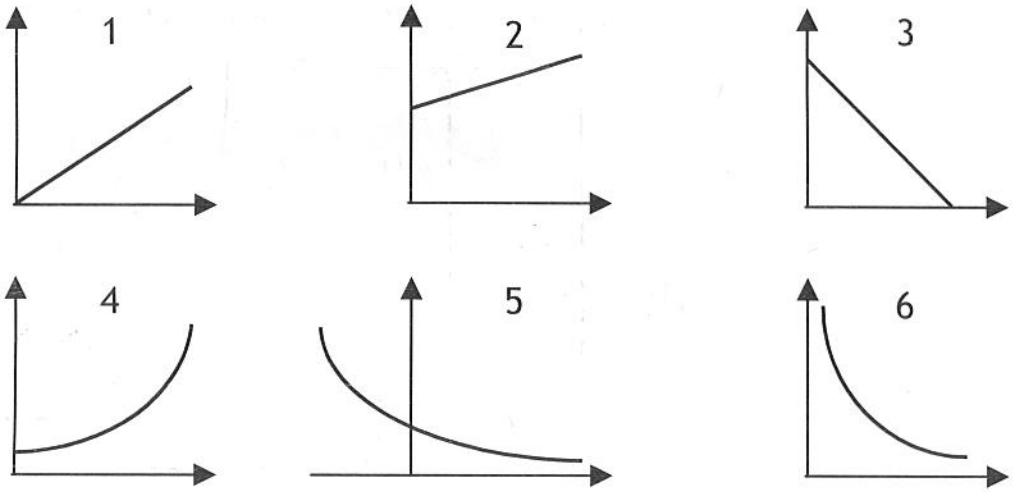
but not same mass !

Question 4

Eminent scientists such as Boyle, Charles and Gay-Lussac contributed to establishing the general gas law by studying the mathematical relationships between the factors that influence the behaviour of ideal gases.

Associate each relationship to one of the graphs below.

	Relationship	
6	Pressure as a function of volume	inverse
2	Volume as a function of temperature in °C	partial
1	Pressure as a function of the number of moles	direct



	Pressure as a function of volume	Volume as a function of temperature in °C	Pressure as a function of the number of moles
A)	graph 6	graph ~~4~~	graph ~~2~~
B)	graph ~~5~~	graph ~~1~~	graph ~~4~~
C)	graph ~~3~~	graph ~~1~~	graph ~~6~~
D)	graph 6	graph 2	graph 1

Question 2

same V, T, P ! ∴ same # moles (n)

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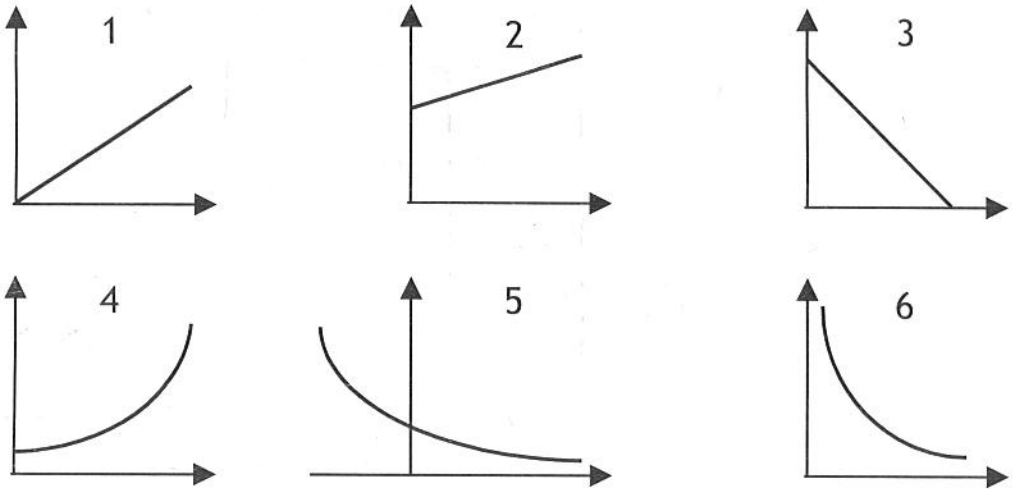

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A)	graph 6	graph ~~4~~	graph ~~2~~
B)	graph ~~5~~	graph ~~1~~	graph ~~4~~
C)	graph ~~3~~	graph ~~1~~	graph ~~6~~
D)	graph 6	graph 2	graph 1

Question 5

as soon as you see the word enthalpy sketch the graph

The formation of gaseous hydrochloric acid, HCl, from its elements is represented by the following reaction:

$$H_{2(g)} + Cl_{2(g)} \rightarrow 2\ HCl_{(g)} + 184.62\ kJ$$ exo!

Four statements about energy changes in reactions are listed below. $\Delta H = -ve$

1. The enthalpy of the reactants is greater than the enthalpy of the products.
2. The enthalpy of the reactants is less than the enthalpy of the products.
3. The change in enthalpy of this reaction is positive.
4. The change in enthalpy of this reaction is negative.

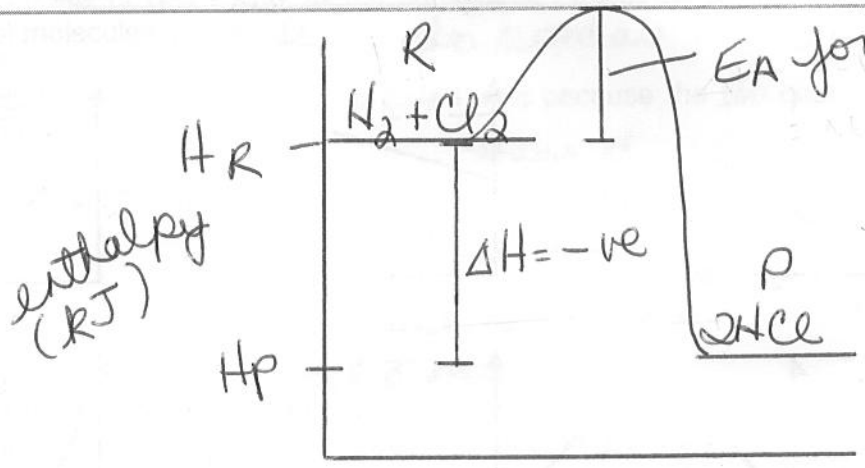
Which two statements are **TRUE** for the formation of gaseous hydrochloric acid?

A) 1 and 3

B) 1 and 4

C) 2 and 3

D) 2 and 4



$\Delta H = H_P - H_R$

Question 6

Consider the following reaction,

$$4\ Fe(OH)_{2(s)} + 2\ H_2O_{(g)} + O_{2(g)} \rightarrow 4\ Fe(OH)_{3(s)}$$

Which algebraic expression for the reaction rate best describes this oxidation?
Assume that the reaction occurs in one step.

A) $r = k\,[Fe(OH)_2]^4\,[H_2O]^2\,[O_2]$

B) $r = k\,[Fe(OH)_2]^4\,[O_2]$

C) $r = k\,[H_2O]^2\,[O_2]^2$

D) $r = k\,[H_2O]^2\,[O_2]$

no solids or liquids

$rate = k\,[H_2O]^2[O_2]$

rate constant

- only the reactants are involved
- conc of R, T of R, nature of R, surface of

Question 7

The reaction of magnesium, Mg, with hydrochloric acid, HCl, is a commonly used to study the rate of reactions.

$$Mg_{(s)} + 2\ HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

If 0.75 g of magnesium is reacted with excess acid, the reaction reaches completion after 1 minute and 30 seconds.

What is the rate of formation of hydrogen, H_2?

A) 3.4×10^{-4} mol/s

B) 4.2×10^{-3} mol/s

C) 8.3×10^{-3} g/s

D) 5.8×10^{-1} g/s

Question 8

Dinitrogen pentoxide, N_2O_5, is one of the nitrogen oxides emitted into the atmosphere by heating systems and cars.

The synthesis of dinitrogen pentoxide in a closed system takes place at high temperature according to the following equation:

$$2\ N_{2(g)} + 5\ O_{2(g)} \rightleftharpoons 2\ N_2O_{5(g)} \qquad \Delta H = 42.5\ kJ/mol$$

Modifications that could be made to this system are listed below.

1. Removing N_2O_5 as it is produced
2. Reducing the temperature
3. Increasing the pressure by reducing the volume
4. Adding a catalyst

Which of the above modifications favour the synthesis of dinitrogen pentoxide?

A) 1 and 2

B) 1 and 3

C) 1 and 4

D) 2 and 3

Question 9

Calcium hydroxide, $Ca(OH)_2$, is a weak base. Its dissociation in water is expressed as follows:

R P

$$Ca(OH)_{2(aq)} \rightleftharpoons Ca^{2+}_{(aq)} + 2OH^-_{(aq)}$$ all aqueous

Which of the expressions below represents the basicity constant, K_b, of calcium hydroxide, $Ca(OH)_2$?

A) $\frac{[Ca(OH)_2]}{[Ca^{2+}][OH^-]^2}$ $K = \frac{[P]^y}{[R]^x}$

B) $\frac{[Ca(OH)_2]}{[Ca^{2+}][OH^-]}$ $K_B = \frac{[Ca^{2+}][OH^-]^2}{[Ca(OH)_2]}$

C) $\frac{[Ca^{2+}][OH^-]^2}{[Ca(OH)_2]}$

D) $\frac{[Ca^{2+}][OH^-]}{[Ca(OH)_2]}$

Question 10

Acetic acid, CH_3COOH, is naturally present in vinegar; it is an antiseptic and a disinfectant. It dissociates in water according to the following equation:

$$CH_3COOH_{(aq)} \rightleftharpoons H^+_{(aq)} + CH_3COO^-_{(aq)} \qquad K_a = 1.74 \times 10^{-5} \text{ at } 25°C$$ → [H+]

A solution of acetic acid with a concentration of 0.1 mol/L has a pH of 2.88 at 25°C. [HA]

What is the concentration of hydroxide ions, OH^-, in the solution?

A) 1.32×10^{-3} mol/L ← question is about [OH-] NOT [H+]

B) 1.74×10^{-5} mol/L

C) 7.58×10^{-12} mol/L • this is a grade 10 question!

D) 1.32×10^{-17} mol/L • don't care about K_A

$pH = -\log[H^+]$

2.88

$[H^+] = 1.32 \times 10^{-3} M$

OR $14 = pH + pOH$

$14 - 2.88 = 11.12$

$pOH = -\log[OH^-]$

$K_W = [H^+][OH^-] = 1 \times 10^{-14}$ at 25°C

Sig fig −1 calculation error! X no sf here 12+16

Question 11

Will the referee allow this ball to be used? Explain your answer.

Show all your work.

$T_2 = -12°C + 273 = 261\,K$ $\quad P_1 = 100.\,kPa$

$V_2 = 4.8\,L$ X same volume X $V_1 = 4.8\,L$

$T_1 = 21 + 273 = 294\,K$

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

100 kPa → 100. kPa 3sf!

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

$$= \frac{(100.\,kPa)(261\,K)}{(294\,K)} = 88.8\,kPa$$

Answer

The pressure of the ball is: 88.8 kPa. 3sf!

Will the referee allow this ball to be used? ☒ Yes ☐ No

Explanation

Bec the P is in the range of acceptable P.

4	3	2	1	0

sig figs ✗ ✓

Question 12

Determine the partial pressure of each of the two gases making up the mixture in the bottle.

Show all your work. Significant figures will be evaluated.

$186.5\ \text{kg}\ CO_2 \times \frac{1000\ \text{g}}{1\ \text{kg}} \times \frac{1\ \text{mol}\ CO_2}{44\ \text{g}} = 4238\ \text{mol}\ CO_2$

$n\ N_2 = \frac{12717\ \text{mol}_T}{} - 4239\ \text{mol}\ CO_2 = 8478\ \text{mol}\ N_2$

$V_T = 1500\ \text{L}$

$T = 15\ ^\circ\text{C} + 273 = 288\ \text{K}$

$P_T = 20\,300\ \text{kPa}$

$PV = nRT$

$n = \frac{PV}{RT} = \frac{(20300\ \text{kPa})(1500\ \text{L})}{\left(8.314\ \frac{\text{kPaL}}{\text{molK}}\right)(288\ \text{K})} = 12717\ \text{moles of gases}$

$P_{CO_2} = \frac{4239\ \text{mol}}{12717\ \text{mol}} \times 20300\ \text{kPa} = 6767\ \text{kPa}$

Answer

- The partial pressure of CO_2 is: 6767 kPa
- The partial pressure of H_2 is: 13533 kP

20 300 kPa P_T

− 6767 kPa P_{CO_2}

13533 kPa P_{H_2}

1.4 × 10⁴ kPa

2pt

4	3	2	1	0

marking guide is wrong re sig figs bec of 1500 L volume = 2sh.

Question 13

What volume of ammonia, NH_3, will be produced?

Show all your work.

$500\,g\,N_2 \times \frac{1\,mol\,N_2}{28\,g} \times \frac{2\,mol\,NH_3}{1\,mol\,N_2} = 35.7\,mol\,NH_3$

$PV = nRT \qquad T = 450°C + 273 = 723\,K$

$V = \frac{nRT}{P} = \frac{(35.7\,mol)(8.314)(723\,K)}{15200\,kPa}$

$V = 14.1\,L$

Answer

The volume of ammonia produced in this reaction is: 14.1 L NH_3.

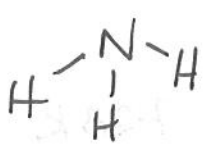
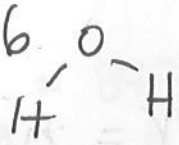
4	3	2	1	0

Question 14

Determine the heat of reaction, ΔH, for the oxidation of ammonia, using the table of average bond enthalpies.

Show all your work.

$4\ NH_3 + 3\ O_2 \rightarrow 2\ N_2 + 6\ H_2O$

4  3 O=O | 2 N≡N 6 

$4 \times 3 \times (N-H) = 12 \times 389 = 4668$ | $2 \times (N \equiv N) = 2 \times 946 = 1892$

$3 \times (O=O) = 3 \times 498 = 1494$ | $6 \times 2 \times (O-H) = 12 \times 464 = 5568$

6162 − 7460

−1268 kJ

The heat of reaction, ΔH, for the oxidation of ammonia is −1298 kJ/mol.

4	3	2	1	0

sig figs ✗ ✓

Question 15

Determine the quantity of energy, in kilojoules, needed to evaporate 14.0 g of water at 25.0°C.

Show all your work.

$H_2O(\ell) \rightarrow H_2O(g) \quad \Delta H = +44 \frac{kJ}{mol}$

$H_2O(\ell) \rightarrow H_2 + \frac{1}{2}O_2$

$H_2 + \frac{1}{2}O_2 \rightarrow H_2O(g)$

Answer $14.0\,g\,H_2O \times \frac{1\,mol\,H_2O}{18.0\,g} \times \frac{44\,kJ}{1\,mol} = 34\,kJ$

The energy needed to evaporate 14.0 g of water at 25.0°C is +34 kJ.

4	3	2	1	0

sig figs

Question 16

What is the minimum temperature the water in the calorimeter will reach if the sample tested is high quality coal?

Show all your work. Significant figures will be evaluated.

$\Delta H = -391\,kJ \times \frac{1\,mol}{12\,g} \times \frac{1000\,J}{1\,kJ} \times 0.80\,g\,C$

$Q = -26067\,J$

$Q_{water} = +26067\,J$

$\frac{Q}{mc} = \frac{mc\Delta T}{mc}$

$\frac{26067\,J}{(250\,g)(4.19\,J/g{\cdot}°C)} = \Delta T = 25°C$

$\Delta T = T_f - T_i$

Answer

The minimum temperature the water must attain is: 50.°C

Q = 26045 if use 12.01 g 1 mol for C!

4	3	2	1	0

Question 17

Calculate the molar heat of neutralization of KOH.

Show all your work.

$Q = m\,c\,\Delta T$

$= (250\,g)\left(4.19\,\frac{J}{g \cdot C}\right)(28.0^{\circ}C - 22.0^{\circ}C)$

$Q_{water} = 6285\,J$

$Q_{rxn} = -6285\,J$

$0.1\,L \times 0.150\,\frac{mol\ KOH}{L} = .0015\,mol\ KOH$

$\Delta H = \frac{Q}{n} = \frac{-6285\,J}{0.0015\,mol\ KOH} =$

$-4.19 \times 10^{3}\,\frac{kJ}{mol.} = -419\,\frac{kJ}{mol.}$

Answer

The molar heat of neutralization of KOH is: $-419\,\frac{kJ}{mol.}$. $-420\,\frac{kJ}{mol}$

4	3	2	1	0

Question 18

Identify the unknown substance by referring to the measurements and table in the ***Student Booklet***.

Show all your work.

$$Q = mc\Delta T$$

$$= (150.00\,g)\left(4.19\,\frac{J}{g\cdot{}^\circ C}\right)(16.5\,^\circ C - 20.5\,^\circ C)$$

$$Q = -2514\,J$$

$$Q_{sub} = +2514\,J = 2.514\,kJ$$ not LiCl bec endo

$$\frac{2.514\,kJ}{7.06\,g} = 0.356\,g$$ KNO_3

$Q = n\Delta H$

$$= \frac{1\,mol}{101.11\,g} \times \frac{36\,kJ}{1\,mol} = 0.356\,g$$

$$\Delta H = \frac{Q}{n}$$

# of g matches bec of ΔH.

Answer

The unknown substance is: KNO_3.

4	3	2	1	0

Question 19

a) How many activated complexes are formed during this transformation?

b) Which step requires the most energy?

c) What is the activation energy of the first step?

d) What is the enthalpy change, ΔH, of the reverse reaction?

a) 3

b) 2

c) + 100 kJ

d) −25 kJ/mol (reverse rxn!)

4	3	2	1	0

Question 20

a) Which factor affecting the reaction rate has caused the shift from graph 1 to graph 2? Explain your answer.

b) Which factor affecting the reaction rate has caused the shift from graph 1 to graph 3? Explain your answer.

a) Factor: catalyst

Explanation: ↓ E_A

b) Factor: ↓ T

Explanation: ↓ E_K of particles

4	3	2	1	0

↑ I

stress = ↑T
want = ↓T
shift = ← since Keq ↓ with means P↓ and R↑

Question 21

Is the decomposition reaction of phosgene, $COCl_2$, endothermic or exothermic?

Explain your answer.

The reaction is: exo.

Explanation:

- ↑T = ↓Keq
- ↓Keq = ↓[CO][Cl_2] / ↑[$COCl_2$]
- ↑$COCl_2$ ⇌ ↓CO + ↓Cl_2 +HE shifted left (Rare favored)
- exo forward

4	2	0

Question 22

Indicate the effect each modification described has on the initial state of equilibrium.

For each of the following procedures, select the correct answer.

	Modifications of the Conditions of the Reaction	Increase of $[B_2H_6]$	Increase amount of B_2O_3	No Effect
a)	Adding a catalyst to the system at equilibrium			X
b)	Adding diborane, B_2H_6, to the system at equilibrium		X	
c)	Increasing the temperature of the system at equilibrium	X		
d)	Adding boron trioxide, B_2O_3, to the system at equilibrium			X

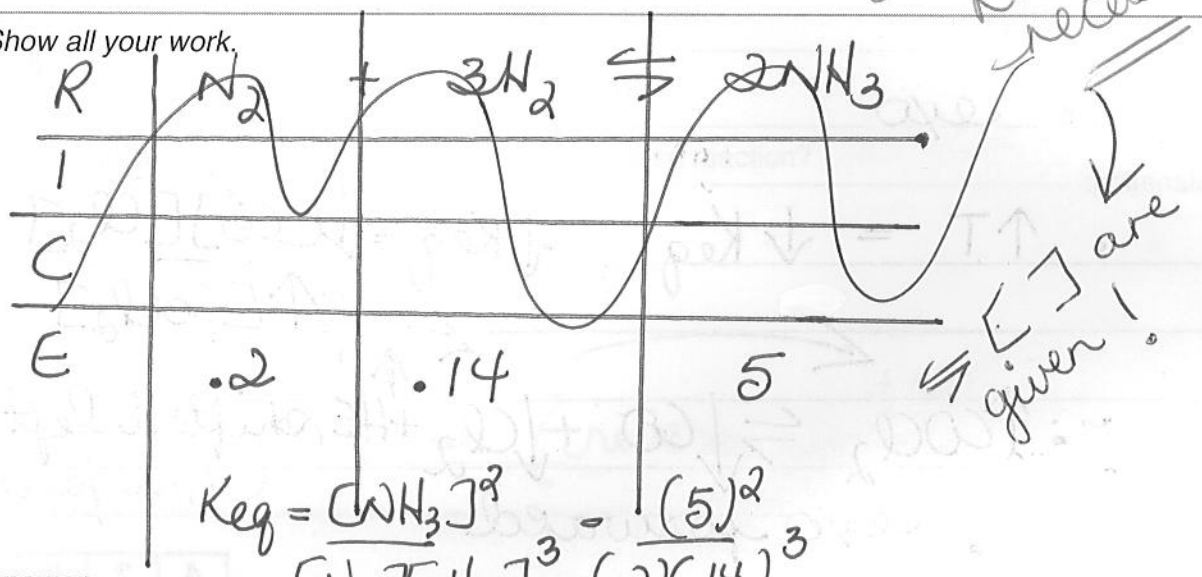
4	3	2	1	0

Question 23

a) What is the equilibrium constant, K_c, of this reaction at 127°C?

no RICE necessary!

Show all your work.



$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3} = \frac{(5)^2}{(.2)(.14)^3}$$

Answer

The equilibrium constant, K_c, of the reaction at 127°C is: 4.6×10^4.

3	2	1	0

b)

2nd time! ↑T

Answer

How will the value of the equilibrium constant, K_c, change if the temperature at which the reaction occurs increases to 400°C?

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3} \uparrow$$

(Circle the correct answer.)

A) The K_c will increase B) The K_c will stay the same (C) The K_c will decrease

The rxn is exothermic. As a result, an ↑ in T will shift the ⇋ in the reverse dir. The [P] will ↓ & the [R] will ↑.

Since $K_{eq} = \frac{[P]\downarrow}{[R]\uparrow} = \uparrow K_{eq}$.

1	0

Question 24

Which of these acids is the strongest?

Show all your work. HF

1) pH 2.60 $[H^+]$ $K_A = \frac{[H^+][F^-]}{[HF]}$

25% ionized ∴ RICE

R	HF ⇌	H^+	+ F^-
I	0.01	Ø	Ø
C			
E	.0075	2.51×10^{-3}	2.51×10^{-3}

$= \frac{(2.51\times10^{-3})^2}{(0.0075)}$

$= 8.4\times10^{-4}$

2) $K_A = 1.8\times10^{-5}$

3) $K_A = \frac{(3.73\times10^{-3})^2}{(0.005 - 0.00373)} = 1.1\times10^{-2}$

Answer

The strongest acid is: 3 ✓ K_A is greatest
$HClO_2$.

4	3	2	1	0

Question 25

Given that its solubility product constant, K_{sp}, is 1.4×10^{-5}, determine the solubility in g/L of this sparingly soluble salt.

Show all your work.

$1\,Ag_2SO_{4(s)} \rightleftharpoons 2Ag^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

$Ksp = [Ag^+]^2[SO_4^{2-}]$

$(2x)\ (x)$

$Ksp = (2x)^2(x)$

$Ksp = 4x^3 = 1.4 \times 10^{-5}$

Ag_2SO_4 molar mass

$x = 0.015\ \frac{mol}{L} \times \frac{312g}{1mol} = \frac{4.68g}{L}$

Answer

The solubility of Ag_2SO_4 is: $\frac{4.7g}{L}$.

4	3	2	1	0