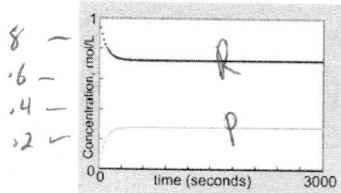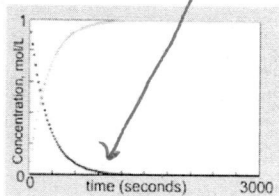QUESTION 1

Use the following concentration-time plots to answer the questions below:
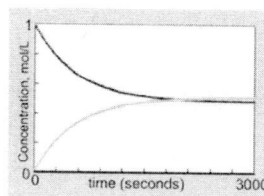
Reactant goes to 0M

8 —
·6 —
.4 —
,2 ✓

R

P

Concentration, mol/L

time (seconds)   3000

a.

Concentration, mol/L

time (seconds)   3000

b.

Concentration, mol/L

time (seconds)   3000

c.

Concentration, mol/L

time (seconds)   3000

d.

Concentration, mol/L

time (seconds)   3000
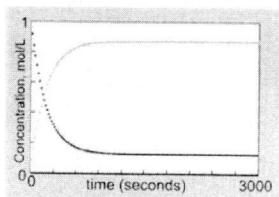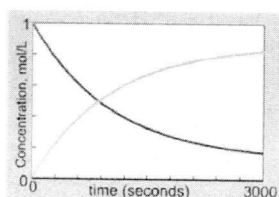
e.

b.

i) Which reaction goes to completion?

ii) Which reaction has the smallest equilibrium constant?   — q. makes the least product

ii) What is the approximate value of K for reaction "a."?

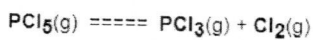iv) Which reaction has the largest equilibrium constant?

↳ b

$[R] \approx 0.72$ $K = \dfrac{0.28m}{0.72m} = 0.39$

$[P] \approx 0.28$

Long Answer Question 4

A student ran the following reaction in the laboratory at **428** K:

PCl$_5$(g) ===== **PCl$_3$(g) + Cl$_2$(g)**

When she introduced **2.71** moles of **PCl$_5$(g)** into a 1.00 liter container, she found the equilibrium concentration of **PCl$_5$(g)** to be **2.68** M.

Calculate the equilibrium constant, K$_c$, she obtained for this reaction.

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$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$

	PCl_5	PCl_3	Cl_2
I	2.71	0	0
C	$-x$	$+x$	$+x$
E	2.68	x	x
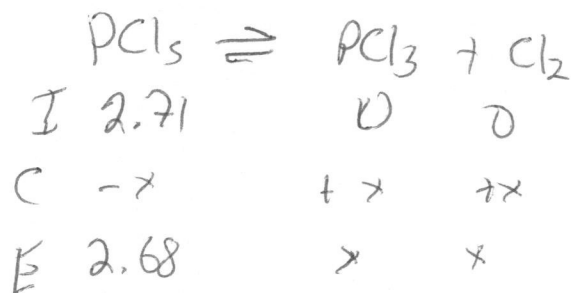
$$x = 2.71 - 2.68 = 0.03$$

$$K = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{(0.03)(0.03)}{2.68} = 3.4 \times 10^{-4}$$

QUESTION 3

List three things that can influence the rate of a reaction:

[ ]
[ ]
[ ]

Temperature   Catalyst
activation energy   Specificity of reaction collision
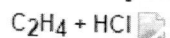Reactant concentrations

QUESTION 4

The solubility of all ionic compounds in water increase with increasing temperature.
○ True   ✗False

QUESTION 5

A reaction profile (not to scale!) for the reaction
$C_2H_4 + HCl$ →

C_2H_5Cl
is shown below:

E (kJ)

205

$E_a = +205 \ kJ/mol$

$C_2H_4 + HCl$

70 $\Delta H = -70 \ kJ/mol$

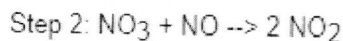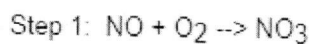C_2H_5Cl

Reaction Coordinate
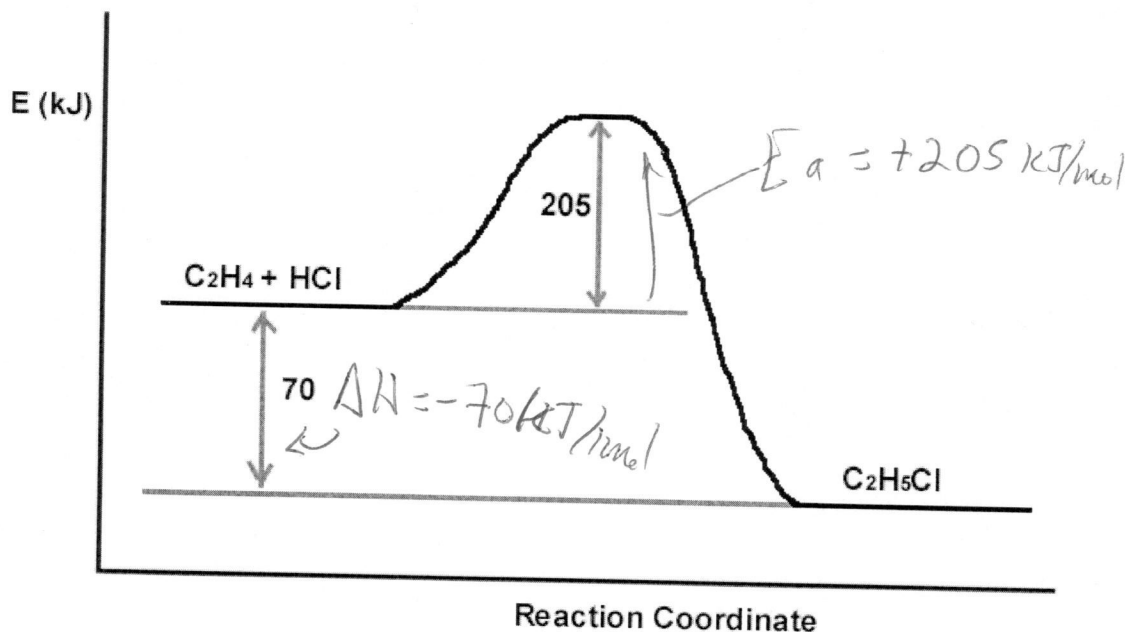
What is the value of the ΔH for this reaction? [ ] kJ/mol

What is the activation energy for this reaction? [ ] kJ/mol

QUESTION 6

Nitrogen monoxide reacts with oxygen to form nitrogen dioxide. One possible mechanism is:

Step 1: NO + O2 --> NO3

Step 2: NO3 + NO --> 2 NO2

Answer without trying to subscript or superscript.

Write the overall reaction: [   ]

$NO + O_2 \rightarrow NO_3$

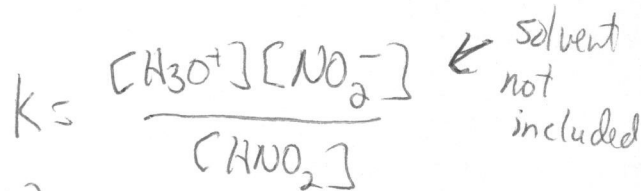$\underline{NO_3 + NO \rightarrow 2NO_2}$

← $2NO + O_2 \rightarrow 2NO_2$
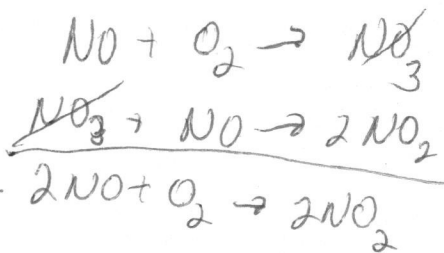
List any intermediates in this mechanism (enter "none" if none): [NO_3]

List any catalysts in this mechanism (enter "none" if none): [None]

QUESTION 7

Long Answer Question:

Write the equilibrium expressions for the following reactions:

$K = \dfrac{[H_3O^+][NO_2^-]}{[HNO_2]}$ ← Solvent not included

a) HNO2(aq) + H2O(l) ===== H3O+(aq) + NO2-(aq)

b) Br2(g) + Cl2(g) ====== 2 BrCl(g)

$K = \dfrac{[BrCl]^2}{[Br_2][Cl_2]}$

c) Ag2SO4(s) ====== 2 Ag+(aq) + SO4 2-(aq) ——————→ $K = [Ag^+]^2[SO_4^{2-}]$
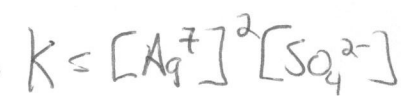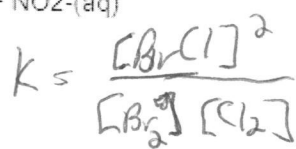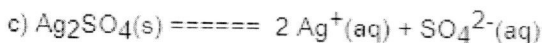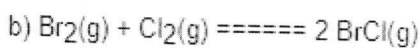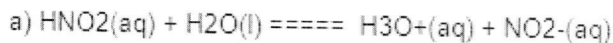
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Solid not included

QUESTION 8

Which of the following compounds is expected to be highly soluble in water.

(☐ a. H2SO4) ← an acid

✗ ☐ b. CH3CH2CH3 } nonpolar

✗ ☐ c. SiCl4

(☐ d. CH3CH2NH2) ← N-bonding

QUESTION 9

The two principle factors controlling whether a chemical reaction will occur are [_____] and [_____].

Thermodynamic   Kinetics

QUESTION 10

Why don't oil and water mix?

QUESTION 11

All gases become more soluble as the partial pressure of the gas over the liquid increases.

(True) ○ False

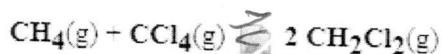## QUESTION 12

he equilibrium constant, K_c, for the following reaction is **5.10** at **394 K**.

$$2 \text{ CH}_2\text{Cl}_2(g) \rightleftharpoons \text{CH}_4(g) + \text{CCl}_4(g)$$

Calculate K_c at this temperature for the following reaction:

$$\text{CH}_4(g) + \text{CCl}_4(g) \rightleftharpoons 2 \text{ CH}_2\text{Cl}_2(g)$$

0.196

reaction reversed, so $K_2 = \dfrac{1}{K_1}$

$$K = \frac{1}{5.10} = 0.196$$

QUESTION 13

Can an aqueous solution of HCl have a negative pH?

(○ yes)

○ no

○ more information is needed

○ no, but it could for a different, stronger acid

for example, 2M HCl, $[\text{H}_3\text{O}^+] = 2.0M$

$-\log(2) = -0.30$

QUESTION 14

What is the pH of a 0.000483 M solution of NaOH? 10.68

What is the concentration of H_3O^+ in this solution? 2.07×10^{-11} M H_3O^+

$$[\text{H}_3\text{O}^+] = 10^{-pH} =$$

$[\text{OH}^-] = 0.000483$

$pOH = 3.316$

$pH = 14 - 3.316$

QUESTION 15

The term "rate constant" implies that a the value of the rate constant cannot change for a given reaction. That is, it cannot change. For a given reaction (without changing the reactants and not adding a catalyst) is it true that the rate constant is indeed constant?

○ True

○ False ← *k changes as temprature changes*

QUESTION 16

The following initial rate data are for the **oxidation of arsenate ion by cerium(IV) ion in aqueous solution**:

$$AsO_3^{3-} + 2\ Ce^{4+} + H_2O \longrightarrow AsO_4^{3-} + 2\ Ce^{3+} + 2\ H^-$$
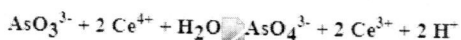
1st order in AsO₃³⁻ [

Experiment	$[AsO_3^{3-}]_o$, M	$[Ce^{4+}]_o$, M	Initial Rate, M s^{-1}
1	1.82×10^{-2}	0.281	7.01×10^{-4}
2	3.64×10^{-2}	0.281	1.40×10^{-3}
3	1.82×10^{-2}	0.562	2.81×10^{-3}
4	3.64×10^{-2}	0.562	5.61×10^{-3}

} *2nd order in Ce⁴⁺*

What is the order of the reaction with respect to AsO_3^{3-}? `1` enter an integer

What is the order of the reaction with respect to Ce^{4+}? `2` enter an integer

What is the overall order of the reaction? `3` enter an integer

← Sum of 1 + 2

QUESTION 17

This is the Arrhenius equation:

$$k = Ae^{-E_a/RT}$$

Rate constant

What does "k" represent? `____`

What does Ea represent? `____` *— activation energy*

If Ea increases, will k increase or decrease? `____` *decrease*

If T increases, will k increase or decrease? `____` *increase*

QUESTION 18

The reaction,

$$NO_2 + CO \longrightarrow NO + CO_2$$

has the rate law,
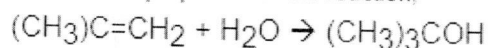
rate $= k\,[NO_2]^2$

[2nd order in NO₂] × 4 the rate ↓

[Zero order in CO] no effect ↓

What effect on the reaction will doubling the concentrations of both NO_2 and of CO have on the reaction rate?

- ⦾ rate does not change
- ⦾ ✗ rate increases by 4 times
- ⦾ rate increases by 8 times
- ⦾ rate increases by 16 times

QUESTION 19

Two mechanisms are proposed for the reaction,

$$(CH_3)C=CH_2 + H_2O \rightarrow (CH_3)_3COH$$

Mechanism A: Step 1. $(CH_3)C=CH_2 + H_2O \rightarrow (CH_3)_3COH$

Mechanism B: Step 1. $(CH_3)C=CH_2 + H^+ \rightarrow (CH_3)_3C^+$ (slow)

Step 2. $(CH_3)_3C^+ + H_2O \rightarrow (CH_3)_3COH$ (fast)

The experimentally determined rate law is: Rate $= k[(CH_3)C=CH_2][H^+]$

Which mechanism is supported by the experimental evidence?

- ⦾ Mechanism A
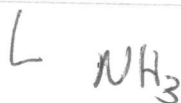- ⦾ Mechanism B
- ⦾ Neither Mechanism
- ⦾ Both Mechanisms

QUESTION 20

Answer without trying to subscript or superscript.

What is the conjugate acid of HSO_3^-? [   ] H_2SO_3

What is the conjugate base of NH_4^+? [   ]

└ NH_3

Long Answer Question 2.

For the **gas phase decomposition of 2,3-dichloropropane**,

$$CH_3CHClCH_2ClCH_3CH=CHCl + HCl$$

the rate constant at 713 K is 0.000919 s^{-1} and the rate constant at 748 K is 0.00565 s^{-1}.

What is the activation energy for this reaction?

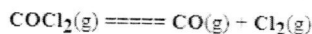$$\ln \frac{k_2}{k_1} = -\frac{E_a}{R}\left[\frac{1}{T_2} - \frac{1}{T_1}\right]$$

$$\ln \frac{0.00565\ s^{-1}}{0.000919\ s^{-1}} = \frac{-E_a}{8.314\frac{J}{K \cdot mol}}\left[\frac{1}{748} - \frac{1}{713}\right]$$

$$1.816 = -\frac{E_a}{R}\left(-6.563\times10^{-5}\right);\quad E_a = 230,000\ J/mol$$

$$= 230\ kJ/mol$$

Long Answer Question 3.

Consider the following reaction:

$$COCl_2(g) ===== CO(g) + Cl_2(g)$$

An equilibrium mixture of the three gases at 753 K contains 1.77×10^{-3} M $COCl_2$, 3.16×10^{-2} M CO, and 4.74×10^{-2} M Cl_2. What is the value of the equilbrium constant at 753 K?

What is the value of the equilibrium constant, K?

$$K = \frac{[CO][Cl_2]}{[COCl_2]} = \frac{(3.16\times10^{-2})(4.74\times10^{-2})}{1.77\times10^{-3}} = 0.846$$

Long Answer Question 1.

Gallium-67 is used medically in tumor-seeking agents. The half-life of **gallium-67** is **78.2 hours**. If you begin with **51.6** mg of this isotope, what mass remains after **123 hours** have passed? Since the decomposition is a radioactive decay reaction, it is first order.

$$k = \frac{0.693}{t_{1/2}} = \frac{0.693}{78.2\,h} = 0.00886\,h^{-1}$$

$$N_t = N_0 e^{-kt} = 51.6\,mg\ e^{-(0.00886\,h^{-1})(123\,h)} =$$

$$\underline{17.3\,mg}$$

$\downarrow$ endothermic

Consider the following system at equilibrium where $K_c = 2.90 \times 10^{-2}$ and $\Delta H° = \underline{198\ kJ/mol}$ at **1150 K**.

$$2\ SO_3\ (g) \rightleftharpoons 2\ SO_2\ (g) + O_2\ (g)$$
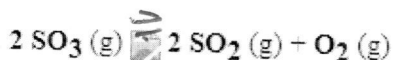
The production of SO_2 (g) is favored by:

i) (increasing or decreasing) the temperature? | increasing |

ii) (increasing or decreasing) the volume? | increasing | ← more moles of gas on product side

iii) (adding or removing) SO3? | adding |

iv) (adding or removing) O2? | removing |