Note: < = > Represents the equilibrium arrow

CHE 107 Exam 2 Fall 2016

Your Name: _____ **Your ID:** _____

Question #: 1

Select the expression below that does **not** define the rate of the reaction
$2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$.

A.

$$\text{Rate} = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t}$$

B.

$$\text{Rate} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t}$$

C.

$$\text{Rate} = -\frac{\Delta[O_2]}{\Delta t}$$

D.

$$\text{Rate} = \frac{\Delta[O_2]}{\Delta t}$$

Question #: 2

For the reaction $P_4(g) + 6\ H_2(g) \rightarrow 4\ PH_3(g)$,

$$\frac{\Delta[H_2]}{\Delta t} = -0.66\ M/s$$

Under the same conditions, the **reaction rate** is __1__ M/s.
Report your answer to the correct number of significant figures. Do **NOT** include units in your answer.

1. _____

Question #: 3

The gas-phase decomposition of NOBr according to the chemical equation below is second order in NOBr. Which of the expressions below could be the rate constant for this reaction?

$$2\ NOBr(g) \rightarrow 2\ NO(g) + Br_2(g)$$

A. $0.80\ M^{-1} \cdot s^{-1}$
B. $2.8 \times 10^{-3}\ s^{-1}$
C. $8.1 \times 10^{2}\ M \cdot s^{-1}$
D. $6.8\ M^{-1} \cdot s^{-2}$

Question #: 4

The table below shows data collected for the reaction:
$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$
The reaction order with respect to NO is __1__ .
The reaction order with respect to O_2 is __2__ .
The overall order of the reaction is __3__ .
Give a numerical answer for each blank.

[NO] (M)	$[O_2]$ (M)	Initial Rate of formation of $[NO_2]$ (M/s)
0.30	0.0055	0.0855
0.30	0.0110	0.171
0.90	0.0110	1.542

1. _____
2. _____
3. _____

Question #: 5

The decomposition of azomethane, $CH_3N_2CH_3$, at 300 °C follows first-order kinetics with a rate constant of $k = 2.55 \times 10^{-3}\ s^{-1}$. How long does it take for the concentration of azomethane to decrease from 0.254 M to 0.0406 M?

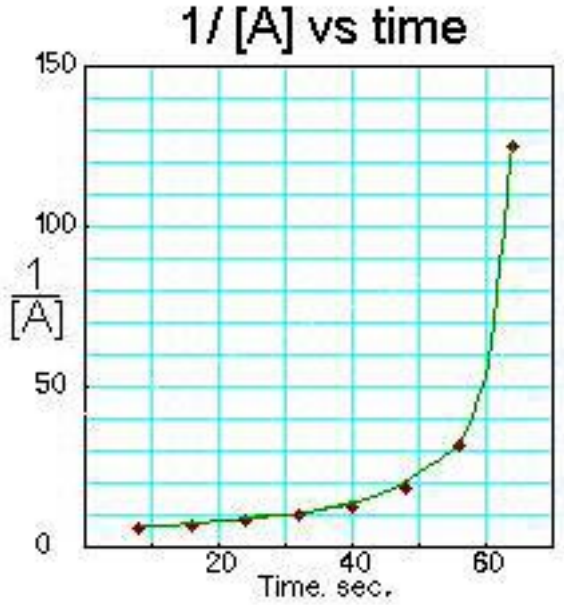
$$CH_3N_2CH_3(g) \rightarrow N_2(g) + C_2H_6(g)$$

A. 110. minutes
B. 760. minutes
C. 12.0 minutes
D. 3.00 minutes

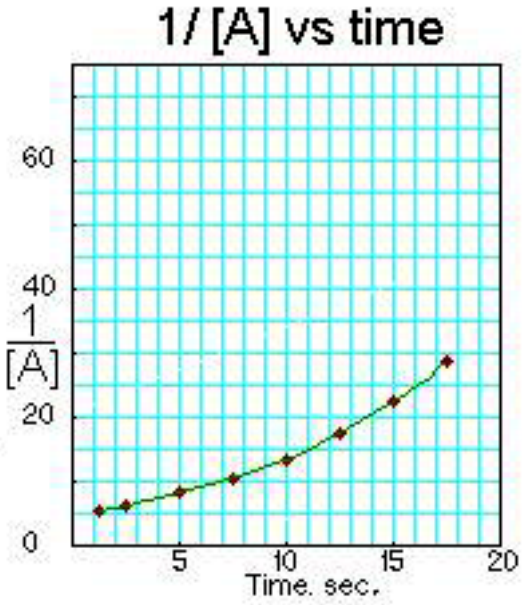
Question #: 6

Which plot shows 1/[A] vs. time for the **second-order** conversion of reactant A to products?

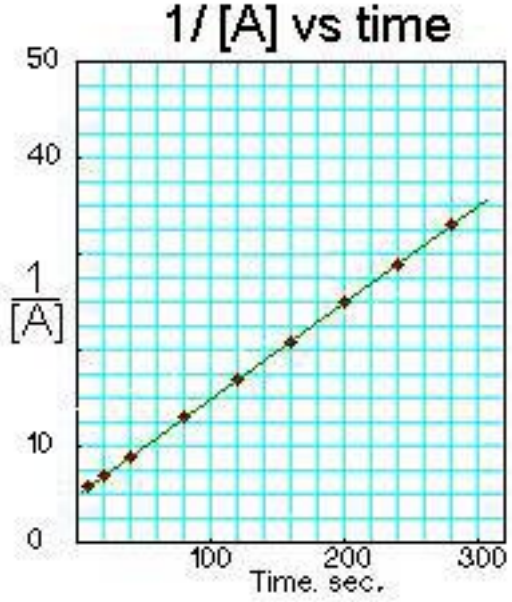
A.



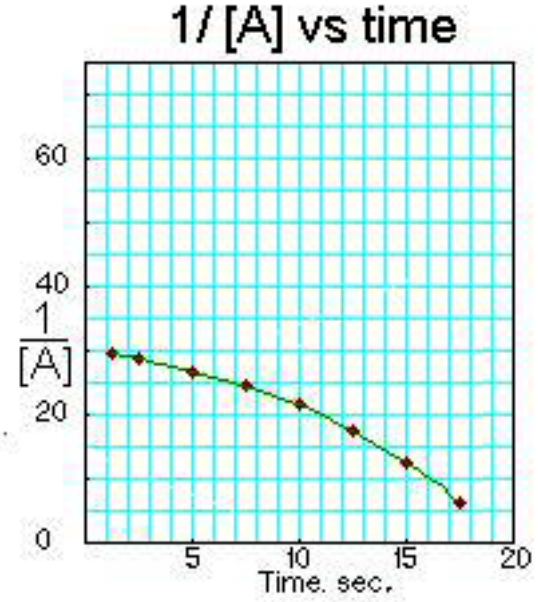
B.



C.


1/ [A] vs time
50
40
1
[A]
10
0
100
200
300
Time. sec.

D.


1/ [A] vs time
60
40
1
[A]
20
0
5
10
15
20
Time. sec.

Question #: 7

The half-life for the first-order decomposition of N_2O_5 is 24 minutes. How long does it take for the N_2O_5 concentration to decrease from 0.80 M to 0.20 M? [Hint: Think before you calculate.]
$N_2O_5(g) \rightarrow 2\ NO_2(g) + ½O_2(g)$

A. 12 min
B. 48 min
C. 24 min
D. 96 min

Question #: 8

The second-order rate constant for the decomposition of nitrous oxide to nitrogen and oxygen
$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$
is 0.011 $M^{-1} \cdot s^{-1}$ at 923 K and 0.24 $M^{-1} \cdot s^{-1}$ at 1023 K. The activation energy for this reaction is __1__ **kJ/mol**.
Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. _____

Question #: 9

According to the collision model, reaction rates increase with increasing temperature mainly because

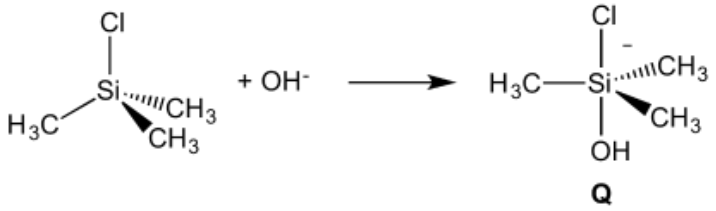
A. the frequency factor (*A* in the Arrhenius equation) increases strongly with increasing temperature.
B. at higher temperature, a larger fraction of intermolecular collisions occurs with the proper orientation to form products.
C. at higher temperature, a larger fraction of intermolecular collisions occurs with sufficient energy to form products by overcoming the activation energy barrier.
D. the activation energy (E_a in the Arrhenius equation) decreases with increasing temperature.

Question #: 10

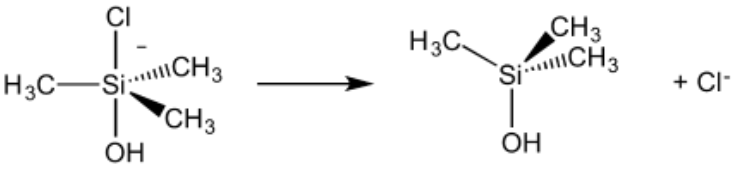
The hydrolysis of $SiCl(CH_3)_3$

$SiCl(CH_3)_3 + OH^- \rightarrow SiOH(CH_3)_3 + Cl^-$

is described by the following two-step reaction mechanism. The species labeled **Q** is a(n) __1__ in this mechanism.

1. 

Q

2. 

1. _____

Question #: 11

The rate law for the reaction

$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$

is

$rate = k[NO][Cl_2]$.

If the proposed mechanism below is correct, what are the relative rates of the two steps?

Step 1: $NO(g) + Cl_2(g) \Leftrightarrow NOCl_2(g)$

Step 2: $NOCl_2(g) + NO(g) \rightarrow 2\ NOCl(g)$

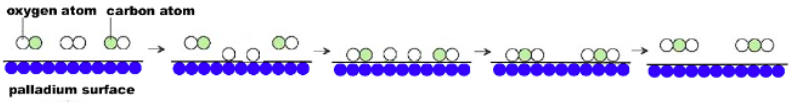
A. Step 1 is faster than Step 2.
B. Step 2 is faster than Step 1.
C. Step 1 and Step 2 proceed at equal rates.

Question #: 12

The figure below shows the oxidation of $CO(g)$ to $CO_2(g)$ on a palladium surface according to the equation

$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$.

The palladium surface acts as a(n) _____.



A. enzyme
B. homogeneous catalyst
C. heterogeneous catalyst
D. reaction intermediate

Question #: 13

Select the **<u>two true</u>** statements about this equilibrium reaction. $K_P = 1.52$ at 700 °C.

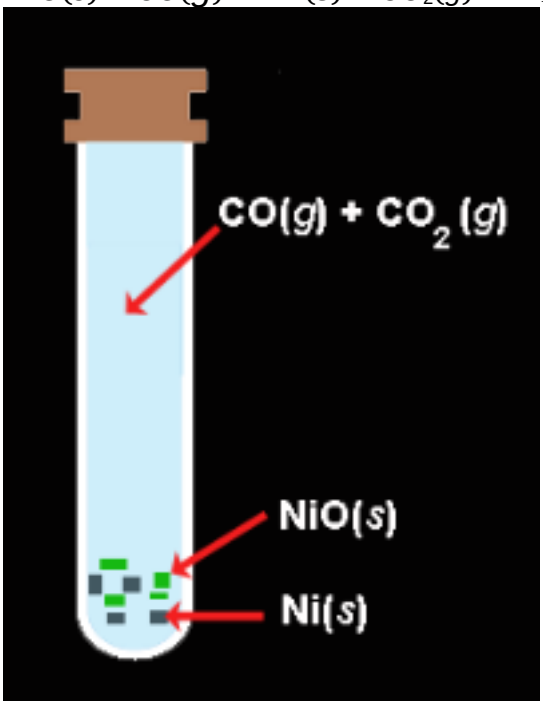
$$COCl_2(g) \underset{k_r}{\overset{k_f}{\rightleftharpoons}} CO(g) + Cl_2(g)$$

A. Pure $COCl_2$ reactant will be converted completely to CO and Cl_2 above 700 °C.
B. At equilibrium, the rate of formation of CO is equal to the rate of consumption of $COCl_2$.
C. Starting with pure $COCl_2$ reactant, the total pressure of the system will rise as it approaches equilibrium.
D. At equilibrium, $k_f = k_r$.

Question #: 14

At 1300 K, NiO(s) is reduced to Ni(s) by CO(g). Select the **two** statements or equations that are **true** about this system.

$NiO(s) + CO(g) \Leftrightarrow Ni(s) + CO_2(g)$ $\quad K_P = 100$



A. $(P_{CO})/100 = P_{CO2}$ at equilibrium.
B. At equilibrium, rate of the forward reaction = rate of the reverse reaction.
C. Starting with **only** NiO(s) and CO(g), the rate of formation of CO_2(g) will be fast initially, then decrease to a slower, constant rate.
D. Adding more Ni(s) to the system at equilibrium will increase P_{CO2}.

Question #: 15

At a certain temperature, the reactions below have the equilbrium constants shown.

$S(s) + O_2(g) \Leftrightarrow SO_2(g)$ $\quad K_{c1} = 4.2 \times 10^{26}$

$2\ S(s) + 3\ O_2(g) \Leftrightarrow 2\ SO_3(g)$ $\quad K_{c2} = 9.8 \times 10^{64}$

What is the equilibrium constant for the reaction below at that temperature?

$2\ SO_2(g) + O_2(g) \Leftrightarrow 2\ SO_3(g)$ $\quad K_{c3} =$ 1

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. _____

Question #: 16

Given

$CH_3OH(g) \Leftrightarrow CO(g) + 2\ H_2(g)$ $K_c = 3.85 \times 10^{-2}$ at 780 °C (1053 K)

what is the value of K_p at 780 °C (1053 K)?

A. 288
B. 26.0
C. 0.358
D. 3.85×10^{-2}

Question #: 17

At high temperatures, magnesium sulfite decomposes to magnesium oxide according to the equation

$MgSO_3(s) \Leftrightarrow MgO(s) + SO_2(g)$

What is the K_P expression for this reaction?

A. $K_P = P_{SO_2}$

B. $K_P = \dfrac{P_{MgO} \cdot P_{SO_2}}{P_{MgSO_3}}$

C. $K_P = (P_{SO_2})^{-1}$

D. $K_P = P_{MgO} \cdot P_{SO_2}$

Question #: 18

Initially, 0.60 moles of NOCl(g) are added to a 2.0 L reaction vessel. At equilibrium, the concentration of NO is 0.099 M. What is K_c for the reaction at this temperature?

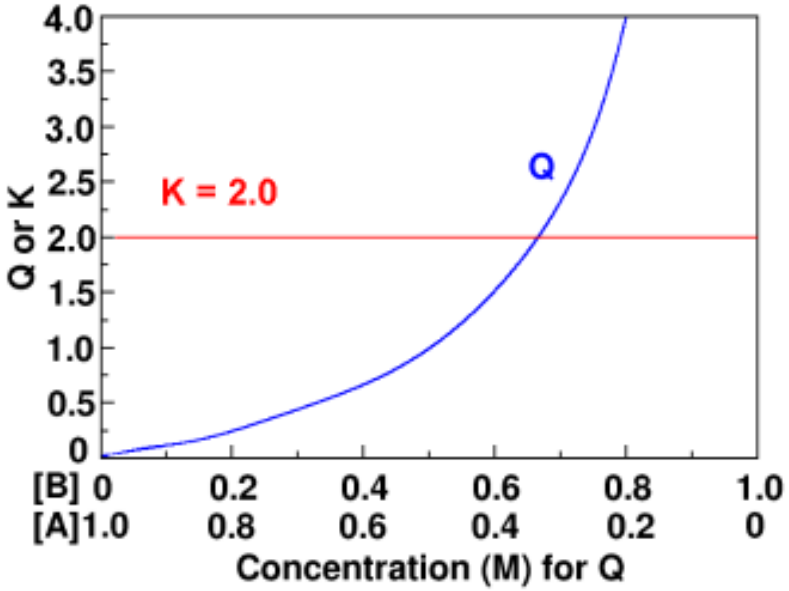
$$2\ NOCl(g) \Leftrightarrow 2\ NO(g) + Cl_2(g) \quad K_c = \underline{\ 1\ }$$

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. _____

Question #: 19

Consider the diagram below displaying the equilibrium constant (K) and the reaction quotient (Q) at the same temperature for the reaction **A** ⇔ **B**.
Which of the following statements is **true**?



A. When [**A**] = 0.3 M and [**B**] = 0.7 M, the reaction proceeds to the right (more **B** forms).
B. When [**A**] = 0.7 M and [**B**] = 0.3 M, the reaction proceeds to the right (more **B** forms).
C. When [**A**] = 0.5 M and [**B**] = 0.5 M, the reaction is at equilibrium.

Question #: 20

When a 184-gram sample of dolomite, $CaMg(CO_3)_2(s)$, is heated quickly to 910 K in a 0.50-liter closed container, the pressure rises to 1.2×10^2 atm. Under these conditions, the reaction quotient is __1__ and the pressure in the container __2__ [**increases, decreases, remains constant**] as the system approaches equilibrium.

$$CaMg(CO_3)_2(s) \rightleftharpoons CaO(s) + MgO(s) + 2\ CO_2(g) \qquad K_P = 2.5 \times 10^4 \text{ at } 900 \text{ K}$$

For answer **1**, report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.
Fill in the correct word or phrase for answer **2**.

1. _____
2. _____

Question #: 21

$TiCl_4$ is usually prepared by the chlorination of TiO_2 according to the equation
$TiO_2(s) + 2\ Cl_2(g) \Leftrightarrow TiCl_4(g) + O_2(g)$ $K_P = 5.4 \times 10^{15}$ at 498 K.
Excess $TiO_2(s)$ reacts with $Cl_2(g)$ in a sealed container. At equilibrium,
$P_{TiCl4} = 3.0$ atm
P_{Cl2} = __1__ atm
P_{O2} = __2__ atm
Report your answers with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. _____
2. _____

Question #: 22

A sample of pure HI(g) with initial pressure 0.33 atm decomposes in a sealed container at 246 K according to:

$2\ HI(g) \Leftrightarrow H_2(g) + I_2(g) \qquad K_P = 0.020$

At equilibrium,

P_{HI} = __1__ atm

P_{H2} = __2__ atm

P_{I2} = __3__ atm

Report your answers with **two** significant figures. Do **NOT** include units in your answer.

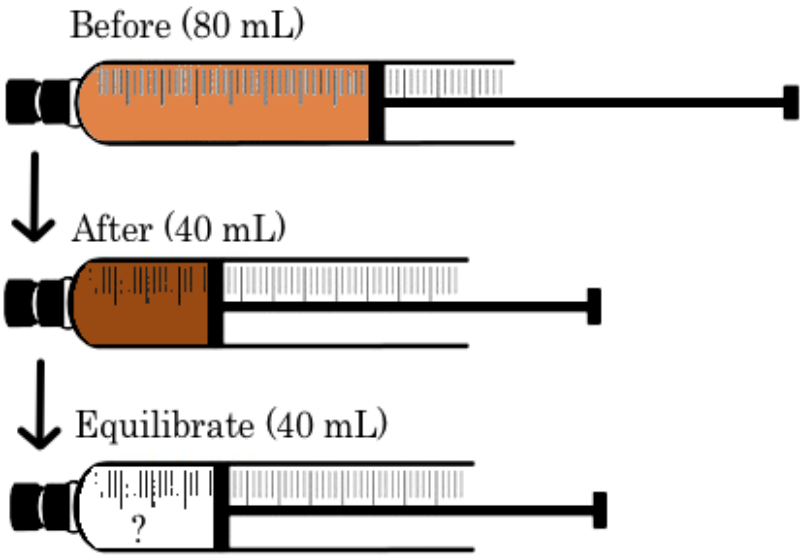
1. _____
2. _____
3. _____

Question #: 23

A gas-tight syringe is filled with a mixture of colorless $H_2(g)$, red-brown $Br_2(g)$ and colorless HBr(g) at equilibrium.

$H_2(g) + Br_2(g) \Leftrightarrow 2\ HBr(g)$

The volume of the syringe is compressed from 80 mL to 40 mL, and the gas mixture darkens. After a minute, the system returns to equilibrium. The color of the gas in the syringe is _____ at equilibrium.



A. darker than "Before."
B. the same as "Before."
C. intermediate between "Before" and "After."
D. the same as "After."
E. lighter than "After."

Question #: 24

At high temperature, methane (CH_4) decomposes to carbon (graphite) and hydrogen in a fixed-volume container according to the following reaction equation.

$CH_4(g) \Leftrightarrow C(graphite) + 2\ H_2(g) \quad \Delta H = 74.9$ kJ/mol

Heat is added to the system at equilibrium (i.e., the temperature is raised).
Select the **two** statements that are **true** in order for the system to return to equilibrium.

A. More $CH_4(g)$ decomposes.
B. No more C(*graphite*) is produced, because C(*graphite*) does not appear in the equilibrium constant expression.
C. The partial pressure of $H_2(g)$ increases.
D. Raising the temperature does not alter the equilbrium pressures.

Question #: 25

Phosphine dissolves in water according to this reaction equation.

$PH_3(g) + H_2O(l) \rightarrow PH_4^+(aq) + OH^-(aq)$

In this reaction, PH_3 acts as a(n) _____.

A. Brønsted-Lowry base
B. Arrhenius base
C. Arrhenius acid
D. Brønsted-Lowry acid

Question #: 26

Which **two** responses identify and classify the Brønsted-Lowry conjugate acid-base pairs in this reaction? (C_5H_5N is pyridine.)

$$C_5H_5N(aq) + H_2O(l) \Leftrightarrow C_5H_5NH^+(aq) + OH^-(aq)$$

A. H_2O, acid; OH^-, conjugate base
B. OH^-, base; H_3O^+, conjugate acid
C. C_5H_5N, base; H_2O, conjugate acid
D. $C_5H_5NH^+$, acid; C_5H_5N, conjugate base

Question #: 27

Four compounds with the pH of a 0.020-molar aqueous solution of each are listed below. Which is the **strongest acid**?

A. F_3CSO_3H, pH = 1.70
B. CH_3NH_3Cl, pH = 6.17
C. H_2SO_3, pH = 1.75
D. $HClO_2$, pH = 1.83

Question #: 28

__1__ is the **strongest acid** and __2__ is the **strongest conjugate base** listed in the table below.
Answer with the **letter only** (**A**–**F**) of each species as it appears in the table.

Acid	K_a	Conjugate Base
A. phenol	1.3×10^{-10}	**D**. phenolate ion
B. hypochlorous acid	3.2×10^{-8}	**E**. hypochlorite ion
C. anilinium ion	2.5×10^{-5}	**F**. aniline

1. _____
2. _____

Question #: 29

Which of these descriptions does **not** characterize the same solution at 25 °C as the other three?

A. pH = 5.27
B. pOH = 8.73
C. $[OH^-] = 1.9 \times 10^{-9}$
D. $[H_3O^+] < [OH^-]$

Question #: 30

The autoionization constant of water is given at three temperatures in the table. In pure water, at which temperature is $[H_3O]^+$ the largest?

°C	K_w
100	5.1×10^{-13}
50	5.5×10^{-14}
0	1.1×10^{-15}

A. 100 °C
B. 50 °C
C. 0 °C
D. $[H_3O]^+ = 1.0 \times 10^{-7}$ M at all temperatures.

DRAFT

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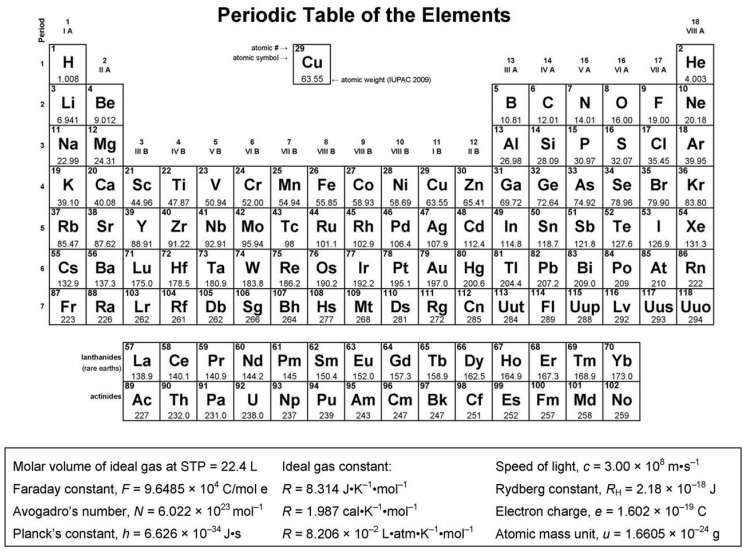
Your Name: _____ **Your ID:** _____



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Question #: 1

Select the expression below that does **not** define the rate of the reaction $2\ N_2O_5(g) \rightarrow 4\ NO_2(g) + O_2(g)$.

A.

$$\text{Rate} = -\frac{1}{2}\frac{\Delta[N_2O_5]}{\Delta t}$$

B.

$$\text{Rate} = \frac{1}{4}\frac{\Delta[NO_2]}{\Delta t}$$

✓C.

$$\text{Rate} = -\frac{\Delta[O_2]}{\Delta t}$$

D.

$$\text{Rate} = \frac{\Delta[O_2]}{\Delta t}$$

Question #: 2

For the reaction $P_4(g) + 6\ H_2(g) \rightarrow 4\ PH_3(g)$,

$$\frac{\Delta[H_2]}{\Delta t} = -0.66\ M/s$$

Under the same conditions, the **reaction rate** is 1 M/s.
Report your answer to the correct number of significant figures. Do **NOT** include units in your answer.

1. 0.11|.11|1.1E-1|+0.11|+.11|+1.1E-1|

Question #: 3

The gas-phase decomposition of NOBr according to the chemical equation below is second order in NOBr. Which of the expressions below could be the rate constant for this reaction?

$$2\ NOBr(g) \rightarrow 2\ NO(g) + Br_2(g)$$

✓A. $0.80\ M^{-1} \cdot s^{-1}$
B. $2.8 \times 10^{-3}\ s^{-1}$
C. $8.1 \times 10^{2}\ M \cdot s^{-1}$
D. $6.8\ M^{-1} \cdot s^{-2}$

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The table below shows data collected for the reaction:

$2\ NO(g) + O_2(g) \rightarrow 2\ NO_2(g)$

The reaction order with respect to NO is __1__ .

The reaction order with respect to O_2 is __2__ .

The overall order of the reaction is __3__ .

Give a numerical answer for each blank.

[NO] (M)	$[O_2]$ (M)	Initial Rate of formation of $[NO_2]$ (M/s)
0.30	0.0055	0.0855
0.30	0.0110	0.171
0.90	0.0110	1.542

1. 2|two|second|2nd|
2. 1|one|first|1st|
3. 3|three|third|thrid|3rd|

Question #: 5

The decomposition of azomethane, $CH_3N_2CH_3$, at 300 °C follows first-order kinetics with a rate constant of $k = 2.55 \times 10^{-3}\ s^{-1}$. How long does it take for the concentration of azomethane to decrease from 0.254 M to 0.0406 M?

$$CH_3N_2CH_3(g) \rightarrow N_2(g) + C_2H_6(g)$$

A. 110. minutes
B. 760. minutes
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Which plot shows 1/[A] vs. time for the **second-order** conversion of reactant A to products?

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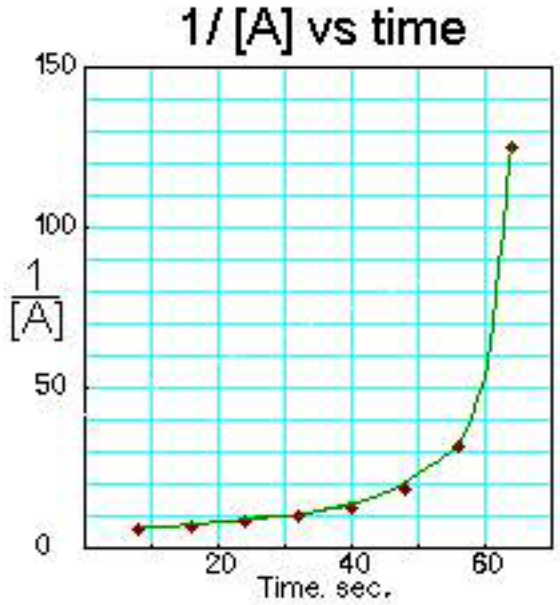
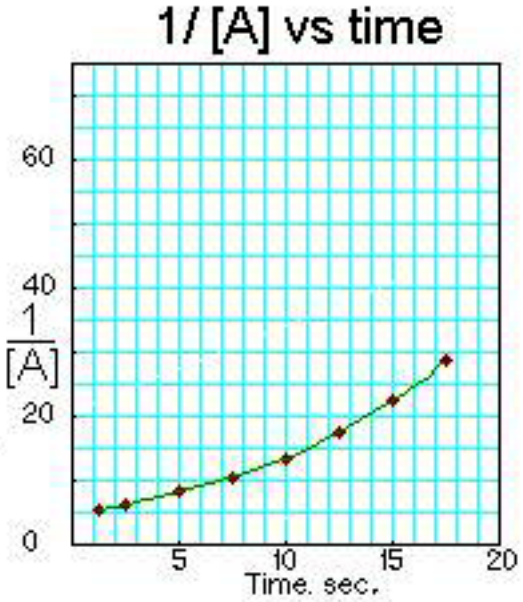
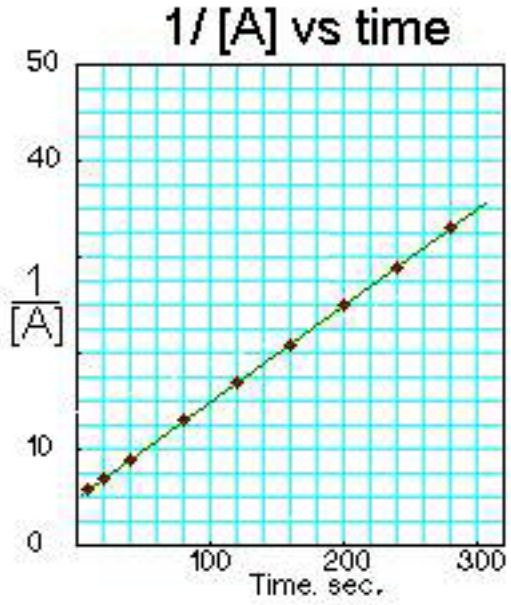

1/ [A] vs time
150
100
1
[A]
50
0
20
40
60
Time. sec.

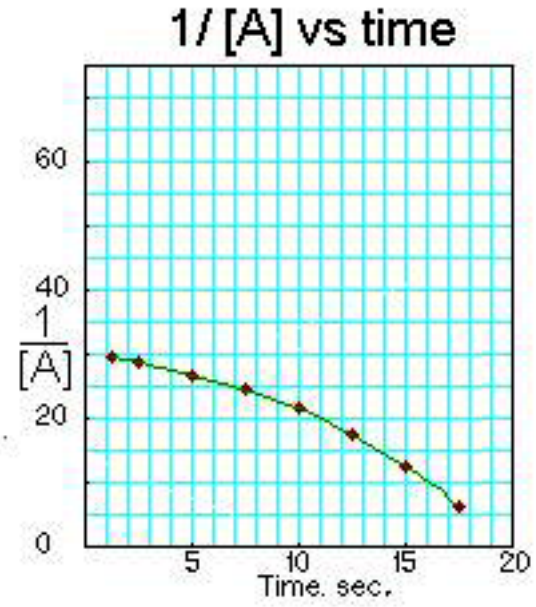
B.


1/ [A] vs time
60
40
1
[A]
20
0
5
10
15
20
Time. sec.

✓C.



D.



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The half-life for the first-order decomposition of N_2O_5 is 24 minutes. How long does it take for the N_2O_5 concentration to decrease from 0.80 M to 0.20 M? [Hint: Think before you calculate.]
$N_2O_5(g) \rightarrow 2\ NO_2(g) + ½O_2(g)$

A. 12 min

✓B. 48 min
C. 24 min
D. 96 min

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The second-order rate constant for the decomposition of nitrous oxide to nitrogen and oxygen

$$2\ N_2O(g) \rightarrow 2\ N_2(g) + O_2(g)$$

is 0.011 $M^{-1} \cdot s^{-1}$ at 923 K and 0.24 $M^{-1} \cdot s^{-1}$ at 1023 K. The activation energy for this reaction is __1__ **kJ/mol**.

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. 240|2.4E2|

Question #: 9

According to the collision model, reaction rates increase with increasing temperature mainly because

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B. at higher temperature, a larger fraction of intermolecular collisions occurs with the proper orientation to form products.
✓C. at higher temperature, a larger fraction of intermolecular collisions occurs with sufficient energy to form products by overcoming the activation energy barrier.
D. the activation energy (E_a in the Arrhenius equation) decreases with increasing temperature.

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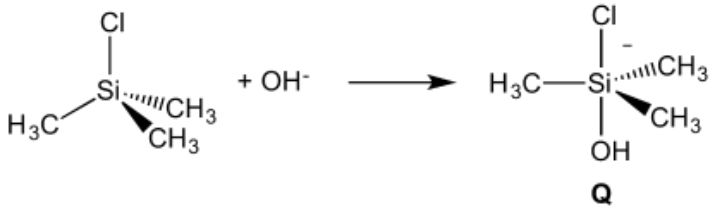
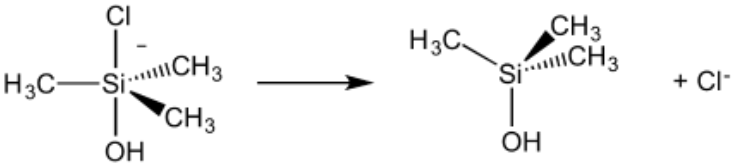
The hydrolysis of $SiCl(CH_3)_3$

$$SiCl(CH_3)_3 + OH^- \rightarrow SiOH(CH_3)_3 + Cl^-$$

is described by the following two-step reaction mechanism. The species labeled **Q** is a(n) __1__ in this mechanism.

1. 

Q

2. 

1. intermediate|innermediate|intermedia|reaction intermediate|

Question #: 11

The rate law for the reaction

$2\ NO(g) + Cl_2(g) \rightarrow 2\ NOCl(g)$

is

$rate = k[NO][Cl_2]$.

If the proposed mechanism below is correct, what are the relative rates of the two steps?

Step 1: $NO(g) + Cl_2(g) \Leftrightarrow NOCl_2(g)$

Step 2: $NOCl_2(g) + NO(g) \rightarrow 2\ NOCl(g)$

A. Step 1 is faster than Step 2.

✓B. Step 2 is faster than Step 1.

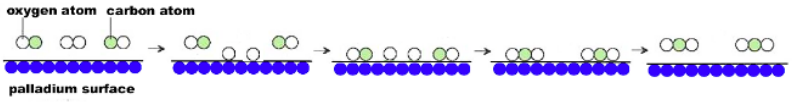
C. Step 1 and Step 2 proceed at equal rates.

Question #: 12

The figure below shows the oxidation of $CO(g)$ to $CO_2(g)$ on a palladium surface according to the equation

$2\ CO(g) + O_2(g) \rightarrow 2\ CO_2(g)$.

The palladium surface acts as a(n) _____.



A. enzyme
B. homogeneous catalyst
✓C. heterogeneous catalyst
D. reaction intermediate

Question #: 13

Select the **two true** statements about this equilibrium reaction. K_P = 1.52 at 700 °C.

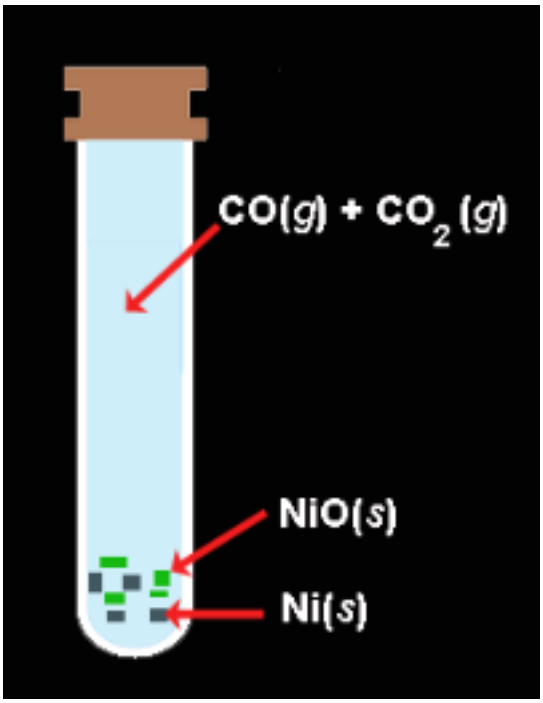
$$COCl_2(g) \underset{k_r}{\overset{k_f}{\rightleftharpoons}} CO(g) + Cl_2(g)$$

A. Pure $COCl_2$ reactant will be converted completely to CO and Cl_2 above 700 °C.
✓B. At equilibrium, the rate of formation of CO is equal to the rate of consumption of $COCl_2$.
✓C. Starting with pure $COCl_2$ reactant, the total pressure of the system will rise as it approaches equilibrium.
D. At equilibrium, $k_f = k_r$.

Question #: 14

At 1300 K, NiO(*s*) is reduced to Ni(*s*) by CO(*g*). Select the **two** statements or equations that are **true** about this system.

$NiO(s) + CO(g) \Leftrightarrow Ni(s) + CO_2(g) \quad K_P = 100$



A. $(P_{CO})/100 = P_{CO2}$ at equilibrium.
✓B. At equilibrium, rate of the forward reaction = rate of the reverse reaction.
✓C. Starting with **only** NiO(*s*) and CO(*g*), the rate of formation of CO_2(g) will be fast initially, then decrease to a slower, constant rate.
D. Adding more Ni(*s*) to the system at equilibrium will increase P_{CO2}.

Question #: 15

At a certain temperature, the reactions below have the equilbrium constants shown.

$S(s) + O_2(g) \Leftrightarrow SO_2(g) \quad K_{c1} = 4.2 \times 10^{26}$

$2\ S(s) + 3\ O_2(g) \Leftrightarrow 2\ SO_3(g) \quad K_{c2} = 9.8 \times 10^{64}$

What is the equilibrium constant for the reaction below at that temperature?

$2\ SO_2(g) + O_2(g) \Leftrightarrow 2\ SO_3(g) \quad K_{c3} =$ 1

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. 5.6E11

Question #: 16

Given

$CH_3OH(g) \Leftrightarrow CO(g) + 2\ H_2(g)$ $K_c = 3.85 \times 10^{-2}$ at 780 °C (1053 K)

what is the value of K_p at 780 °C (1053 K)?

✓A. 288
B. 26.0
C. 0.358
D. 3.85×10^{-2}

Question #: 17

At high temperatures, magnesium sulfite decomposes to magnesium oxide according to the equation

$MgSO_3(s) \Leftrightarrow MgO(s) + SO_2(g)$

What is the K_P expression for this reaction?

✓A.
$$K_P = P_{SO_2}$$

B.
$$K_P = \frac{P_{MgO} \cdot P_{SO_2}}{P_{MgSO_3}}$$

C.
$$K_P = (P_{SO_2})^{-1}$$

D.
$$K_P = P_{MgO} \cdot P_{SO_2}$$

Question #: 18

Initially, 0.60 moles of NOCl(g) are added to a 2.0 L reaction vessel. At equilibrium, the concentration of NO is 0.099 M. What is K_c for the reaction at this temperature?

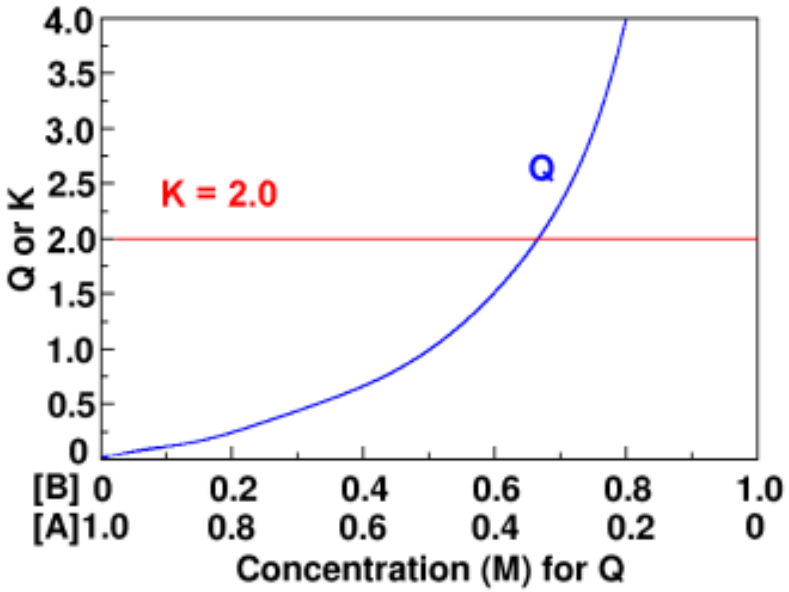
$$2\ NOCl(g) \Leftrightarrow 2\ NO(g) + Cl_2(g) \quad K_c = \underline{\ 1\ }$$

Report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. 0.012|1.2E-2|.012|1.2 E-2|1.2x10^-2|1.2 x 10^-2|

Question #: 19

Consider the diagram below displaying the equilibrium constant (*K*) and the reaction quotient (*Q*) at the same temperature for the reaction **A** ⇔ **B**.
Which of the following statements is **true**?



A. When [**A**] = 0.3 M and [**B**] = 0.7 M, the reaction proceeds to the right (more **B** forms).
✓B. When [**A**] = 0.7 M and [**B**] = 0.3 M, the reaction proceeds to the right (more **B** forms).
C. When [**A**] = 0.5 M and [**B**] = 0.5 M, the reaction is at equilibrium.

Question #: 20

When a 184-gram sample of dolomite, $CaMg(CO_3)_2(s)$, is heated quickly to 910 K in a 0.50-liter closed container, the pressure rises to 1.2×10^2 atm. Under these conditions, the reaction quotient is __1__ and the pressure in the container __2__ [**increases, decreases, remains constant**] as the system approaches equilibrium.

$CaMg(CO_3)_2(s)$
$\rightleftharpoons$

$CaO(s) + MgO(s) + 2\ CO_2(g)$ $\quad K_P = 2.5 \times 10^4$ at 900 K

For answer **1**, report your answer with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.
Fill in the correct word or phrase for answer **2**.

1. 1.4E4|1.4 E4|
2. increases|increase|rise|rises|

Question #: 21

$TiCl_4$ is usually prepared by the chlorination of TiO_2 according to the equation
$TiO_2(s) + 2\ Cl_2(g) \Leftrightarrow TiCl_4(g) + O_2(g)$ $\quad K_P = 5.4 \times 10^{15}$ at 498 K.
Excess $TiO_2(s)$ reacts with $Cl_2(g)$ in a sealed container. At equilibrium,
P_{TiCl4} = 3.0 atm
P_{Cl2} = 1 atm
P_{O2} = 2 atm
Report your answers with **two** significant figures. Do **NOT** include units in your answer. Report your answer in scientific notation with the format 2.2E2 or 2.2E-2.

1. 4.1E-8|4.0E-8|4.2E-8|
2. 3.0|3.0E0|

Question #: 22

A sample of pure $HI(g)$ with initial pressure 0.33 atm decomposes in a sealed container at 246 K according to:
$2\ HI(g) \Leftrightarrow H_2(g) + I_2(g)$ $\quad K_P = 0.020$
At equilibrium,
P_{HI} = 1 atm
P_{H2} = 2 atm
P_{I2} = 3 atm

Report your answers with **two** significant figures. Do **NOT** include units in your answer.

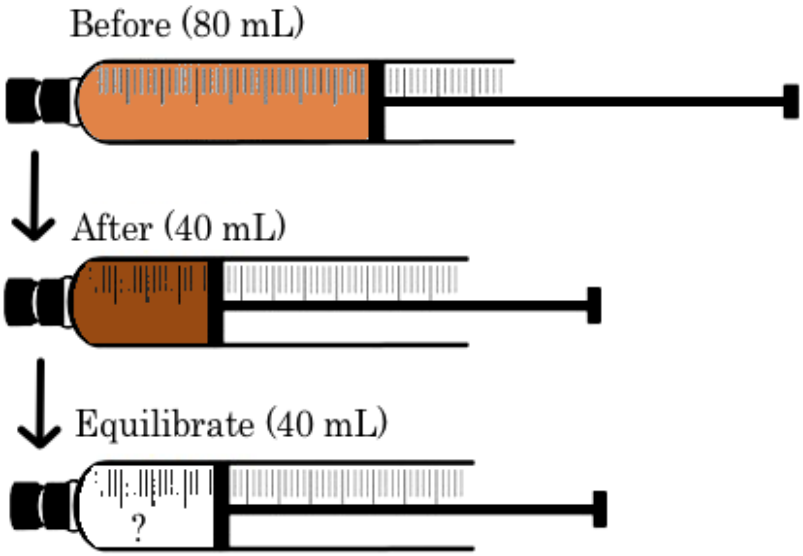
1. 0.26
2. 0.036
3. 0.036

Question #: 23

A gas-tight syringe is filled with a mixture of colorless $H_2(g)$, red-brown $Br_2(g)$ and colorless HBr(g) at equilibrium.

$$H_2(g) + Br_2(g) \Leftrightarrow 2\ HBr(g)$$

The volume of the syringe is compressed from 80 mL to 40 mL, and the gas mixture darkens. After a minute, the system returns to equilibrium. The color of the gas in the syringe is _____ at equilibrium.



A. darker than "Before."
B. the same as "Before."
C. intermediate between "Before" and "After."
✓D. the same as "After."
E. lighter than "After."

Question #: 24

At high temperature, methane (CH_4) decomposes to carbon (graphite) and hydrogen in a fixed-volume container according to the following reaction equation.

$CH_4(g) \Leftrightarrow C(graphite) + 2\ H_2(g) \quad \Delta H = 74.9$ kJ/mol

Heat is added to the system at equilibrium (i.e., the temperature is raised).

Select the **two** statements that are **true** in order for the system to return to equilibrium.

✓A. More $CH_4(g)$ decomposes.
B. No more C(*graphite*) is produced, because C(*graphite*) does not appear in the equilibrium constant expression.
✓C. The partial pressure of $H_2(g)$ increases.
D. Raising the temperature does not alter the equilbrium pressures.

Question #: 25

Phosphine dissolves in water according to this reaction equation.

$PH_3(g) + H_2O(l) \rightarrow PH_4^+(aq) + OH^-(aq)$

In this reaction, PH_3 acts as a(n) _____.

✓A. Brønsted-Lowry base
B. Arrhenius base
C. Arrhenius acid
D. Brønsted-Lowry acid

Question #: 26

Which **two** responses identify and classify the Brønsted-Lowry conjugate acid-base pairs in this reaction? (C_5H_5N is pyridine.)

$$C_5H_5N(aq) + H_2O(l) \Leftrightarrow C_5H_5NH^+(aq) + OH^-(aq)$$

✓A. H_2O, acid; OH^-, conjugate base
B. OH^-, base; H_3O^+, conjugate acid
C. C_5H_5N, base; H_2O, conjugate acid
✓D. $C_5H_5NH^+$, acid; C_5H_5N, conjugate base

Question #: 27

Four compounds with the pH of a 0.020-molar aqueous solution of each are listed below. Which is the **strongest acid**?

✓A. F_3CSO_3H, pH = 1.70
B. CH_3NH_3Cl, pH = 6.17
C. H_2SO_3, pH = 1.75
D. $HClO_2$, pH = 1.83

Question #: 28

1 is the **strongest acid** and 2 is the **strongest conjugate base** listed in the table below.

Answer with the **letter only** (**A**–**F**) of each species as it appears in the table.

Acid	K_a	Conjugate Base
A. phenol	1.3×10^{-10}	**D**. phenolate ion
B. hypochlorous acid	3.2×10^{-8}	**E**. hypochlorite ion
C. anilinium ion	2.5×10^{-5}	**F**. aniline

1. C|c|C.|c.|
2. D|d|D.|d.|

Question #: 29

Which of these descriptions does **not** characterize the same solution at 25 °C as the other three?

A. pH = 5.27
B. pOH = 8.73
C. $[OH^-] = 1.9 \times 10^{-9}$
✓D. $[H_3O^+] < [OH^-]$

Question #: 30

The autoionization constant of water is given at three temperatures in the table. In pure water, at which temperature is $[H_3O]^+$ the largest?

°C	K_w
100	5.1×10^{-13}
50	5.5×10^{-14}
0	1.1×10^{-15}

✓A. 100 °C
B. 50 °C
C. 0 °C
D. $[H_3O]^+ = 1.0 \times 10^{-7}$ M at all temperatures.