CHEM 104
PLI 29 Mock Exam
Tuesday, July 12, 2016 Mock Exam I

1. Interferon is a water-soluble, non-dissociating protein. A 2.50 mL solution prepared by dissolving 15.0 mg of interferon in water exhibits an osmotic pressure of 5.80 mm Hg at 25 °C. What is the molar mass of interferon?

2. Assuming complete dissociation, which 0.10 *m* electrolyte solution will show the largest freezing point depression?

   (A) HCl
   (B) $NaNH_4$
   (C) $CaBr_2$
   (D) $MgSO_4$
   (E) K_3PO_4

3. The half-life of a first-order reaction is 1.5 hours. How much time is needed for 94% of the reactant to change to product?

4. When the kinetics of the reaction, $2A + 2B \rightarrow C$ were studied using the method of initial rates, the data in the table below were obtained.

Trial	$[A]_0$ (M)	$[B]_0$ (M)	Initial Rate of Formation of C (M/s)
1	0.060	0.040	3.6×10^{-4}
2	0.060	0.080	7.2×10^{-4}
3	0.030	0.120	5.4×10^{-4}

What is the rate law for the reaction?

5. For the reaction $5O_{2(g)} + 4NH_{3(g)} \rightarrow 4NO_{(g)} + 6H_2O_{(g)}$, if NH_3 is being consumed at a rate of 0.50 M/s, at what rate is H_2O being formed?

6. A solution of 5.00 g of which ionic solid, in 1 L of solution at 25 °C, has the largest osmotic pressure?

(A) $CaBr_2$ (molar mass = 199.9 g/mol)
(B) RbF (molar mass = 104.5 g/mol)
(C) $AlBr_3$ (molar mass = 266.7 g/mol)
(D) KNO_3 (molar mass = 101.1 g/mol)
(E) NaI (molar mass = 149.9 g/mol)

7. A substance XY decomposes in a second-order reaction. A solution that is initially 1.00 M in XY requires 0.50 hours for its concentration to decrease to 0.50 M. How much time will it take for a solution of XY to decrease in concentration from 2.00 M to 0.25 M?

Passage II (Questions 8–14)

A chemist interested in the reactivity of iodine concentrated his study on two reactions: the decomposition of gaseous hydrogen iodide (Reaction 1) and the reaction between iodide ions and persulfate ions (Reaction 2).

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

Reaction 1

$$3I^-(aq) + S_2O_8^{2-}(aq) \rightleftharpoons I_3^-(aq) + 2SO_4^{2-}(aq)$$

Reaction 2

The value of the rate constant for Reaction 1 was studied as a function of temperature. The results are shown below.

Table 1

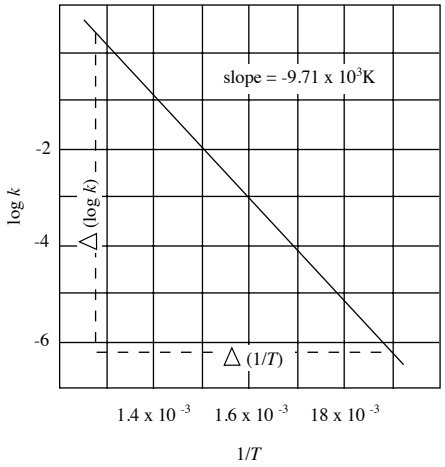
T(K)	$1/T$ (K^{-1})	k ($l \cdot mol^{-1}sec^{-1}$)	log k
555	1.80×10^{-3}	3.52×10^{-7}	–6.453
575	1.74×10^{-3}	1.22×10^{-6}	–5.913
645	1.55×10^{-3}	8.59×10^{-5}	–4.066
700	1.43×10^{-3}	1.16×10^{-3}	–2.936
781	1.28×10^{-3}	3.95×10^{-2}	–1.403

For any reaction, the activation energy (E_a) is related to the rate constant *(k)* by the Arrhenius equation (Equation 1):

$$k = A \times 10^{(-Ea \,/\, 2.303RT)}$$

Equation 1

where R = 8.314 J $mol^{-1}K^{-1}$, T is the temperature in Kelvin, and A is a constant, called the frequency factor. Figure 1 shows a graph of log k vs. $1/T$ for Reaction 1.



In order to determine the initial rate of Reaction 2, the following data were collected:

Table 2

Experiment	$[I^-]$ (M)	$[S_2O_8^{-2}]$ (M)	Initial rate of reaction (M / sec)
1	0.21	0.15	1.14
2	0.21	0.30	2.28
3	0.42	0.15	2.28

8. What is the rate law for Reaction 2?

A. Rate = $k[I^-]^2[S_2O_8^{2-}]$
B. Rate = $k[S_2O_8^{2-}]$
C. Rate = $k[I^-][S_2O_8^{2-}]$
D. Rate = $k[I^-][S_2O_8^{2-}]^2$

9. What is the numerical value of the rate constant for Reaction 2?

A. 7.6 mol/L•sec
B. 36 mol/L•sec
C. 172 mol/L•sec
D. 241 mol/L•sec

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10. According to Equation 1:

A. when the temperature is held constant, the lower the activation energy, the slower the reaction.
B. when the activation energy is held constant, the lower the value of *A*, the faster the reaction.
C. when the activation energy is held constant, the lower the temperature, the faster the reaction.
D. when the temperature is held constant, the lower the activation energy, the faster the reaction.

11. What is the activation energy for Reaction 1?

A. 9.71 kJ/mole
B. 22.4 kJ/mole
C. 80.7 kJ/mole
D. 186 kJ/mole

12. In Figure 1, what does the intercept with the *y*-axis represent?

A. log *A*

B. log *k*

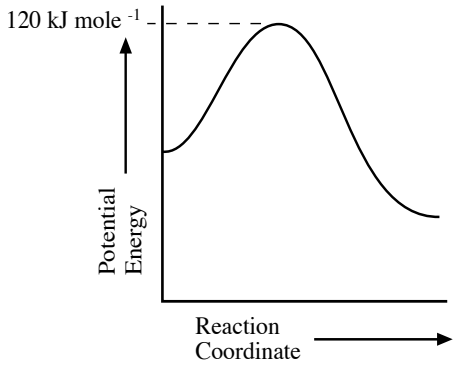
C. $-E_a$

D. $-\frac{1}{RT}$

13. If the rate of disappearance of I^- in Reaction 2 is 2.5×10^{-3} mol/(L•s), what is the rate of formation of SO_4^{2-}?

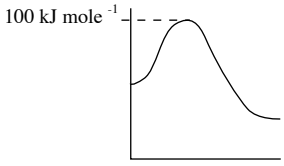
A. 1.7×10^{-3} mol/(L•s)
B. 3.8×10^{-3} mol/(L•s)
C. 5.0×10^{-3} mol/(L•s)
D. 8.3×10^{-4} mol/(L•s)

14. The reaction profile shown below is for an uncatalyzed reaction.

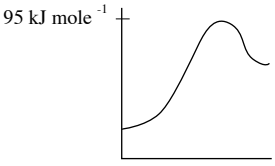


Which of the following is the reaction profile for the same reaction after the addition of a catalyst?

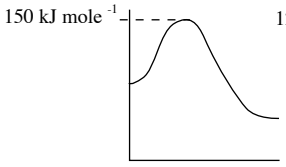
A.



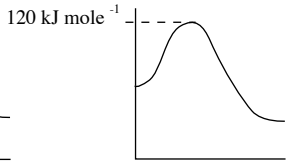
C.



B.



D.



15. A reaction has a rate constant $k = 8.54 \times 10^{-4}\ M^{-1}s^{-1}$ at 45 ºC, and an activation energy $E_a = 90.8$ kJ. What is the value of k at 25 ºC?

16. What is the mole fraction of CH_3OH in an aqueous solution that is 12.0 *m* in CH_3OH?

17. For the reaction, $2A + B \rightarrow C + D$, the rate law is: Rate = $k[B]$.

    Which of the following mechanisms is consistent with this information?

(A)	$A + B \rightarrow M$	(slow)
	$A + M \rightarrow C + D$	(fast)
(B)	$A + A \rightarrow M$	(fast)
	$B \rightarrow C + D$	(slow)
(C)	$B \rightarrow M$	(slow)
	$A + M \rightarrow N$	(fast)
	$N + A \rightarrow C + D$	(fast)
(D)	$B \rightarrow M$	(fast)
	$A + M \rightarrow N$	(slow)
	$N + A \rightarrow C + D$	(fast)
(E)	$A + A \rightarrow M$	(slow)
	$M + B \rightarrow C + D$	(fast)

18. Which of the following decreases with increasing intermolecular forces?

    (A) Boiling point
    (B) Molar enthalpy of vaporization ($\Delta_{vap}H^{o}$)
    (C) Vapor pressure
    (D) Viscosity
    (E) Surface tension

19. The Henry's Law constant for oxygen gas in water at 25 °C $k_{O2} = 1.3 \times 10^{-3}$ M/atm. What is the partial pressure of O_2 above a solution at 25 °C with an O_2 concentration of 2.3×10^{-4} M at equilibrium?

20. Which mixture of water and H_2SO_4 represents a solution with a concentration that is closest to 30% by mass H_2SO_4?

    (A) 30 g H_2SO_4 + 100 g H_2O
    (B) 1 mol H_2SO_4 + 200 g H_2O
    (C) 30 mol H_2SO_4 + 0.70 kg H_2O
    (D) 0.30 mol H_2SO_4 + 0.70 mol H_2O
    (E) 0.30 mol H_2SO_4 + 100 mol H_2O

21. The vapor pressure of water at 31 °C is 33.7 mmHg. When you dissolve 931.0 g of acetone (CH_3COCH_3) in 32.50 kg of water, what is the vapor pressure of water over the solution at 31 °C?

22. The data below were collected for this reaction at 500 °C: CH3CN **(g)** ⟶ CH3NC **(g)**

Time (hr)	**[CH_3CN] (M)**
0.0	1.000
5.0	0.794
10.0	0.631
15.0	0.501
20.0	0.393
25.0	0.316

a) What is the order of the reaction? Please briefly explain your reasoning.

b) What is the value of the rate constant at this temperature?

c) What is the half-life for this reaction (at the initial concentration)?

d) How long will it take for 90% of the CH3CN to convert to CH3NC?

23. During the winter, much of the salt you see melting ice is calcium chloride, which has a solubility of 74.5 g per 100.0g of cold water. What is the lowest temperature ice that calcium chloride salt can melt assuming complete dissociation?

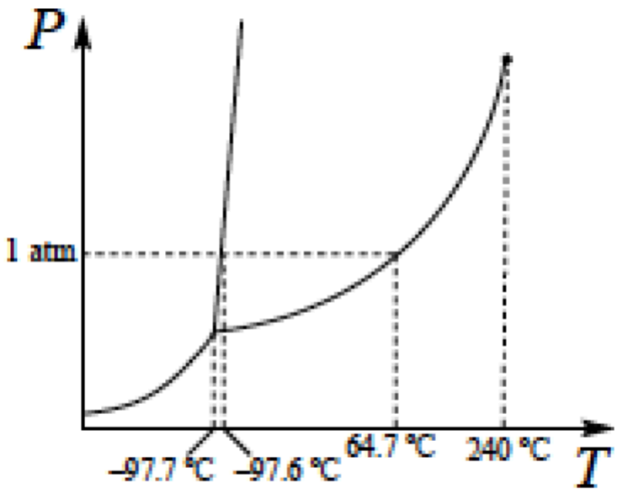
24. The data shown below were collected for the second-order reaction:

$$Cl_2\ \mathbf{(g)} + 2\ H_2\ \mathbf{(g)} \rightarrow 2\ HCl\ \mathbf{(g)} + H_2\ \mathbf{(g)}$$

Temp. (K)	**Rate Constant ($M^{-1}\ s^{-1}$)**
90	0.00357
100	0.0773
110	0.956

Please determine the activation energy and frequency factor for the reaction.

25. Below is the phase diagram of methanol:



a) True or False:

i. _____ Solid methanol is denser than liquid methanol.

ii. _____ Solid methanol sublimes at atmospheric pressure.

iii. _____ Solid, liquid, and gaseous methanol cannot coexist at atmospheric pressure.

iv. _____ It is possible to have liquid methanol at –100 °C.

v. _____ It is possible to have gaseous methanol at 1 atm.

b) What is the boiling point of methanol at atmospheric pressure? _____

c) What is the freezing point of methanol at atmospheric pressure? _____