

Student Name: _____

Recitation Section Number: _____

Recitation Instructor: _____

The exam has 25 questions for credit and an additional one to check the color of your exam booklet. Please answer all 26 questions **on the OpScan sheet**. There is no penalty for guessing. At the end of the 80-minute exam period, please hand in only *this* top sheet and your OpScan form. If you finish early, please do not disturb your fellow students. A proctor will check your picture-ID, OpScan form and signature *during* the exam. Exam scores and an exam curve will be posted as soon as possible.

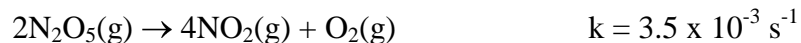
ON THE OpScan FORM: (Use a Number 2 Pencil or Darker)

- (1) SIGN your name across the TOP of the form.
- (2) code only the following information: **[blacken circles]**
 - (a) Your Name . . . LAST NAME FIRST
[blank space between last and first names]
 - (b) Your SOCIAL SECURITY NUMBER
[Start under Box A and continue to Box I]
 - (c) Your RECITATION SECTION NUMBER (Boxes **K & L**)
[Sections R1=51, R2=52, R3=53, R4 = 54]
 - (d) Your EXAM FORM NUMBER (Box **P**)

Your EXAM FORM is: ①

See last pages of exam for physical constants, periodic table, and other information.

1. A sample of gaseous N_2O_5 decomposes according to the following first-order reaction:



How long will it take for the concentration of N_2O_5 to drop to 65.0% of its original value?

- A. 14 s
B. 35 s
C. 65 s
D. 103 s
E. 123 s
2. A 4.03 M aqueous solution of the antifreeze ethylene glycol ($\text{C}_2\text{H}_6\text{O}_2$) has a density of 1.045 g/cm^3 . What is the mass percent of ethylene glycol in this solution? (Molar mass of $\text{C}_2\text{H}_6\text{O}_2$ is 62.07 g/mol .)
- A. 23.9%
B. 16.7%
C. 76.0%
D. 33.6%
E. 5.9%
3. Which of the following statements would be correct regarding the following reaction?
- $$2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$$
- A. The rate of O_2 disappearance is twice the rate of H_2 disappearance.
B. The rate of H_2 disappearance is equal to the rate of O_2 disappearance.
C. The rate of H_2O disappearance is twice the rate of O_2 disappearance.
D. The rate of H_2O appearance is equal to the rate of O_2 disappearance.
E. The rate of H_2 disappearance is twice the rate of O_2 disappearance.

4. The half-life for the first order decomposition of sulfuryl chloride at 320°C is 8.75 h.



What is the pressure of sulfuryl chloride 4.00 hours after the start of the reaction, if its initial pressure is 722 mm Hg?

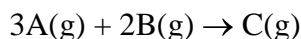
- A. 569 mm Hg
B. 526 mm Hg
C. 501 mm Hg
D. 463 mm Hg
E. 392 mm Hg
5. The unit of the rate constant for the following rate law equation is:
- $$\text{Rate} = k[\text{A}][\text{B}]^2$$
- A. $\text{M}^{-1} \text{s}^{-1}$
B. s^{-1}
C. Ms^{-1}
D. $\text{M}^{-2} \text{s}^{-1}$
E. $\text{M}^{-2} \text{s}$
6. In a first-order reaction, $\text{X} \rightarrow \text{products}$, the initial concentration of X is 0.400 M and its concentration drops to 0.250 M after 15.0 min. Calculate the half-life of the reaction:
- A. 18.3 min.
B. 22.1 min.
C. 28.5 min.
D. 36.2 min.
E. 78.9 min
7. To 1000 g of water containing 0.010 mole of NaCl, 10.0 g of ethyl alcohol, $\text{C}_2\text{H}_5\text{OH}(\ell)$ are added. Which quantity remains the same?
- A. the molality of NaCl
B. the mass percentage of NaCl
C. the mole fraction of NaCl
D. the molarity of NaCl
E. the vapor pressure of water

8. Which statement is correct?
- A. A saturated solution contains a high concentration of solute.
 - B. A saturated solution involves a dynamic equilibrium between dissolving and crystallization.
 - C. The solubility of solids always increases with temperature.
 - D. The solubility of a gas usually increases with temperature.
 - E. A supersaturated solution involves a dynamic equilibrium between solute and solution.
9. Which statement is not true regarding colligative properties?
- A. The magnitude depends on the concentration.
 - B. The magnitude depends on whether the solute is an electrolyte or not.
 - C. The magnitude depends on the identity of the solute.
 - D. Raoult's Law describes the vapor pressure above a solution.
 - E. Since the vapor pressure of the solvent is lowered by a nonvolatile solute, the boiling point of the solution is higher.
10. The rate constant for the decomposition of N_2O_5 [$2\text{N}_2\text{O}_5(\text{g}) \rightarrow 4\text{NO}_2(\text{g}) + \text{O}_2(\text{g})$] at 25°C is $3.1 \times 10^{-5} \text{ s}^{-1}$. Calculate the initial rate for the decomposition of N_2O_5 at 25°C when the initial concentration of N_2O_5 is 0.045 M .
- A. $2.5 \times 10^{-6} \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$
 - B. $6.3 \times 10^{-8} \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$
 - C. $3.8 \times 10^{-8} \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$
 - D. $4.6 \times 10^{-6} \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$
 - E. $1.4 \times 10^{-6} \text{ mol}\cdot\text{L}^{-1}\cdot\text{s}^{-1}$

11. Which solution has the highest boiling point?
- A. 0.1 m urea
 - B. 0.06 m HCl
 - C. 0.05 m CaCl₂
 - D. 0.04 m (NH₄)₃PO₄
 - E. 0.07 m NaCl
12. Which one of the following solutes would you expect to be most soluble in water?
- A. CH₃OH
 - B. C₂H₆
 - C. CHCl₃
 - D. CCl₄
 - E. CH₄
13. Find the mass of the nonvolatile solute naphthalene, C₁₀H₈, which must be added to 200.0 g benzene to produce a boiling point elevation of 1.0 K (k_b for benzene is 2.53 K kg mol⁻¹; molar mass of naphthalene is 128 g/mol).
- A. 10.1 g
 - B. 22.4 g
 - C. 50.6 g
 - D. 18.3 g
 - E. 30.8 g
14. Calculate the mole fraction of heptane in vapor above the solution containing 0.200 mol of liquid heptane and 0.300 mol of liquid octane. The vapor pressures of pure heptane and octane are 92.0 Torr and 32.2 Torr, respectively.
- A. 0.656
 - B. 0.488
 - C. 0.588
 - D. 0.414
 - E. 0.533

15. Which one of the following is true when a catalyst is added to a reaction?
- A. The activation energy usually increases.
 - B. The enthalpy of the reaction is lowered.
 - C. The rate law remains the same.
 - D. The amounts of products and reactants do not change.
 - E. The rate constant decreases.

16. Initial rate data obtained for the following reaction is tabulated.



<u>[A]₀, M</u>	<u>[B]₀, M</u>	<u>Initial rate, M/s</u>
0.100 M	0.200 M	0.0418
0.100 M	0.400 M	0.0834
0.200 M	0.200 M	0.333

What is the rate law?

- A. Rate = $k [A]^3 [B]^2$
 - B. Rate = $k [A] [B]^3$
 - C. Rate = $k [A]^3 [B]$
 - D. Rate = $[A] [B]^2$
 - E. Rate = $k [A]^2 [B]$
17. The van't Hoff factor for $MgCl_2$ in a solution is 2.450. What is its fractional dissociation?
- A. 0.575
 - B. 0.640
 - C. 0.920
 - D. 0.725
 - E. 0.830
18. The mass % and mole fraction of an unknown solute in an aqueous solution are 21.0 % and 0.0220, respectively. What is the molar mass of the unknown solute?
- A. 213 g/mol
 - B. 143 g/mol
 - C. 261 g/mol
 - D. 337 g/mol
 - E. 179 g/mol

19. What is the boiling point of a benzene solution that freezes at 1.02°C below the freezing point of pure benzene?

$$k_f = 5.12^{\circ}\text{C}/\text{m} \quad ; \quad k_b = 2.53^{\circ}\text{C}/\text{m} \quad ; \quad \text{B.P.} = 80.00^{\circ}\text{C}$$

- A. 80.50°C
B. 80.76°C
C. 80.65°C
D. 80.95°C
E. 80.40°C
20. The molarity of a reactant in a second-order reaction falls from 0.150 M to 0.130 M in 30.0 s . What is the instantaneous rate of disappearance of the reactant at 30.0 s ?
- A. $-5.78 \times 10^{-4}\text{ M/s}$
B. $-2.30 \times 10^{-3}\text{ M/s}$
C. $-8.00 \times 10^{-4}\text{ M/s}$
D. $-1.20 \times 10^{-3}\text{ M/s}$
E. $-9.78 \times 10^{-4}\text{ M/s}$
21. A sample of $\text{N}_2\text{O}_5(\text{g})$ is placed in a flask at 0.800 atm . After 45.0 s , the pressure of $\text{N}_2\text{O}_5(\text{g})$ falls to 0.550 atm . What is the average rate of appearance of $\text{O}_2(\text{g})$ during this time? (N_2O_5 decomposes to O_2 and N_2)
- A. $1.67 \times 10^{-2}\text{ atm/s}$
B. $1.39 \times 10^{-2}\text{ atm/s}$
C. $4.34 \times 10^{-2}\text{ atm/s}$
D. $3.89 \times 10^{-2}\text{ atm/s}$
E. $5.00 \times 10^{-2}\text{ atm/s}$
22. An aqueous solution of 9.45 g of an enzyme has a volume of 1.50 L at 27°C . The osmotic pressure of the solution is 0.850 torr . Calculate the molar mass of the enzyme.
- A. $1.81 \times 10^5\text{ g/mol}$
B. $1.18 \times 10^5\text{ g/mol}$
C. $1.39 \times 10^5\text{ g/mol}$
D. $1.27 \times 10^5\text{ g/mol}$
E. $1.57 \times 10^5\text{ g/mol}$

23. The **rate** of a second-order reaction is 2.50×10^{-2} M/s when the reactant concentration is 0.150 M. What is the half-life of the reaction at this concentration?
- A. 7.00 s
 - B. 6.00 s
 - C. 4.00 s
 - D. 5.00 s
 - E. 8.00 s
24. The slope of an Arrhenius plot between $\ln k$ and $\frac{1}{T}$ for a reaction is -1.32×10^4 K. What is the activation energy of the reaction?
- A. 289 kJ/mol
 - B. 148 kJ/mol
 - C. 110 kJ/mol
 - D. 78.4 kJ/mol
 - E. 197 kJ/mol
25. At 25°C and 1.0 atm of gas pressure, the solubility of CO₂ is 149mg/100g H₂O. A 300g sample of pure water is shaken in air under a pressure of 0.850 atm at 25°C. If the mole fraction of CO₂ in the air sample is 0.00840, what is the mass of CO₂ that will be present in the water when solubility equilibrium is reached?
- A. 2.15mg
 - B. 3.19mg
 - C. 4.34mg
 - D. 5.45mg
 - E. 6.97mg
26. What is the color of your exam?
- A. White
 - B. Pink

Reference Equations

$$C = kP$$

$$\Delta T = iK_f m$$

$$\Delta T = iK_b m$$

$$P_{\text{solution}} = X_{\text{solvent}} P_{\text{solvent}}^0$$

$$\pi = iMRT$$

$$t_{1/2} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k} \ln \frac{[A]_0}{[A]_{1/2}}$$

$$\ln \frac{[A]_t}{[A]_0} = -kt$$

$$\frac{1}{[A]_t} - \frac{1}{[A]_0} = kt$$

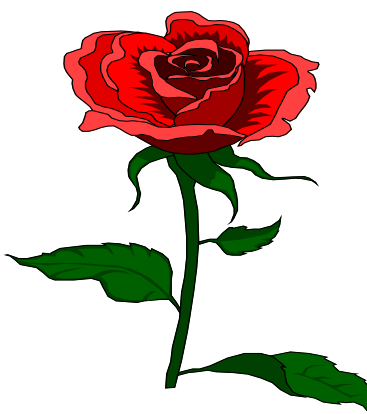
$$t_{1/2} = \frac{\ln 2}{k}$$

$$[A]_t = [A]_0 - kt$$

$$R = 0.0821 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K} = 8.31 \text{ J mol}^{-1}\text{K}^{-1}$$

$$\ln k = \ln A - \frac{E_a}{RT}$$

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



HAPPY VALENTINE'S DAY!