Chemistry 122	Winter 2006	Oregon State University
Final Exam	March 22, 2005	Dr. Richard Nafshun

DO NOT OPEN THIS EXAM UNTIL INSTRUCTED.
CALCULATORS ARE NOT TO BE SHARED.

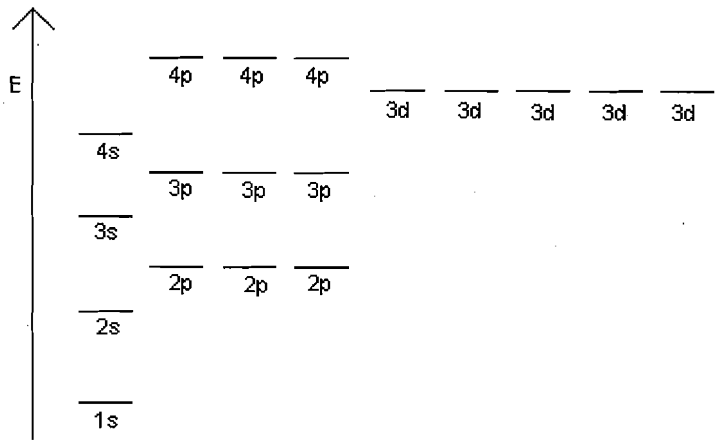
Test Form 2

Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the room.

Fill in the front page of the Scantron answer sheet with your test form number (listed above), last name, first name, middle initial, and student identification number. **Leave the class section number blank.**

This exam consists of 37 multiple-choice questions. Each question has four points associated with it—except Question 37 which has six. Select the best multiple-choice answer by filling in the corresponding circle on the rear page of the answer sheet. If you have any questions before the exam, please ask. If you have any questions during the exam, please ask the proctor. Open and start this exam when instructed. When finished, place your Scantron form and note card in the appropriate stacks. You may keep the exam packet, so please show your work and mark the answers you selected on it.

R = 0.0821 L•atm/mol•K	760 mm Hg = 760 torr = 1 atm	m = mol/kg
M = mol/L	$\Delta T_f = imk_f$	$\Delta T_b = imk_b$
$\Pi V = nRT$	$k_f (H_2O) = 1.86$ °C/m	$k_b(H_2O) = 0.512$ °C/m
$\ln[\frac{A}{A_o}] = -kt$	$k = Ae^{\frac{-Ea}{RT}}$	$K_a (CH_3COOH) = 1.8 \times 10^{-5}$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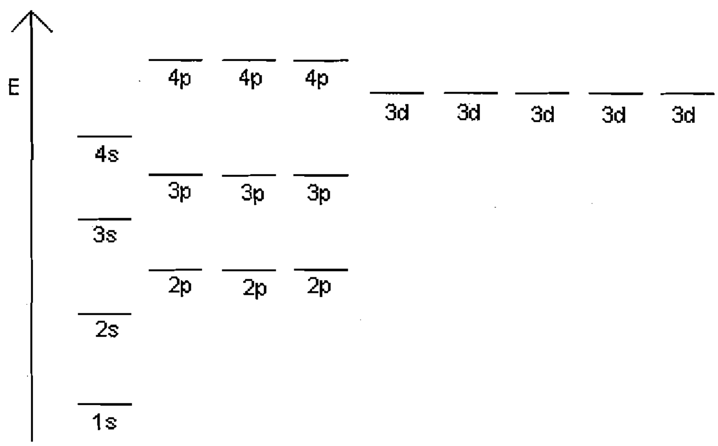
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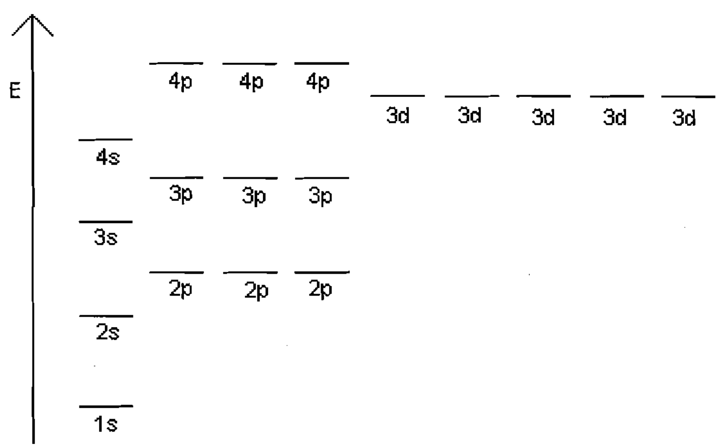
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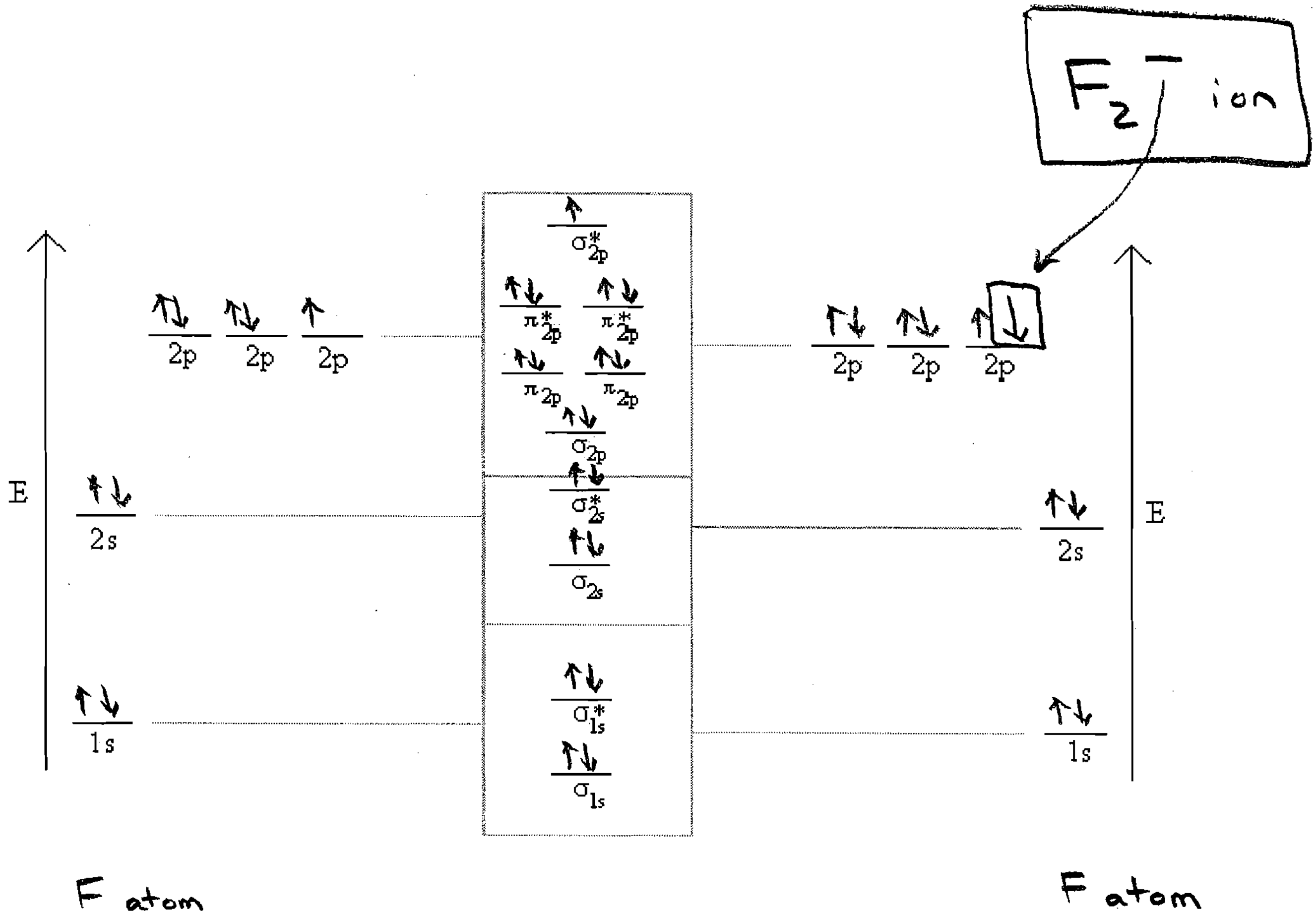

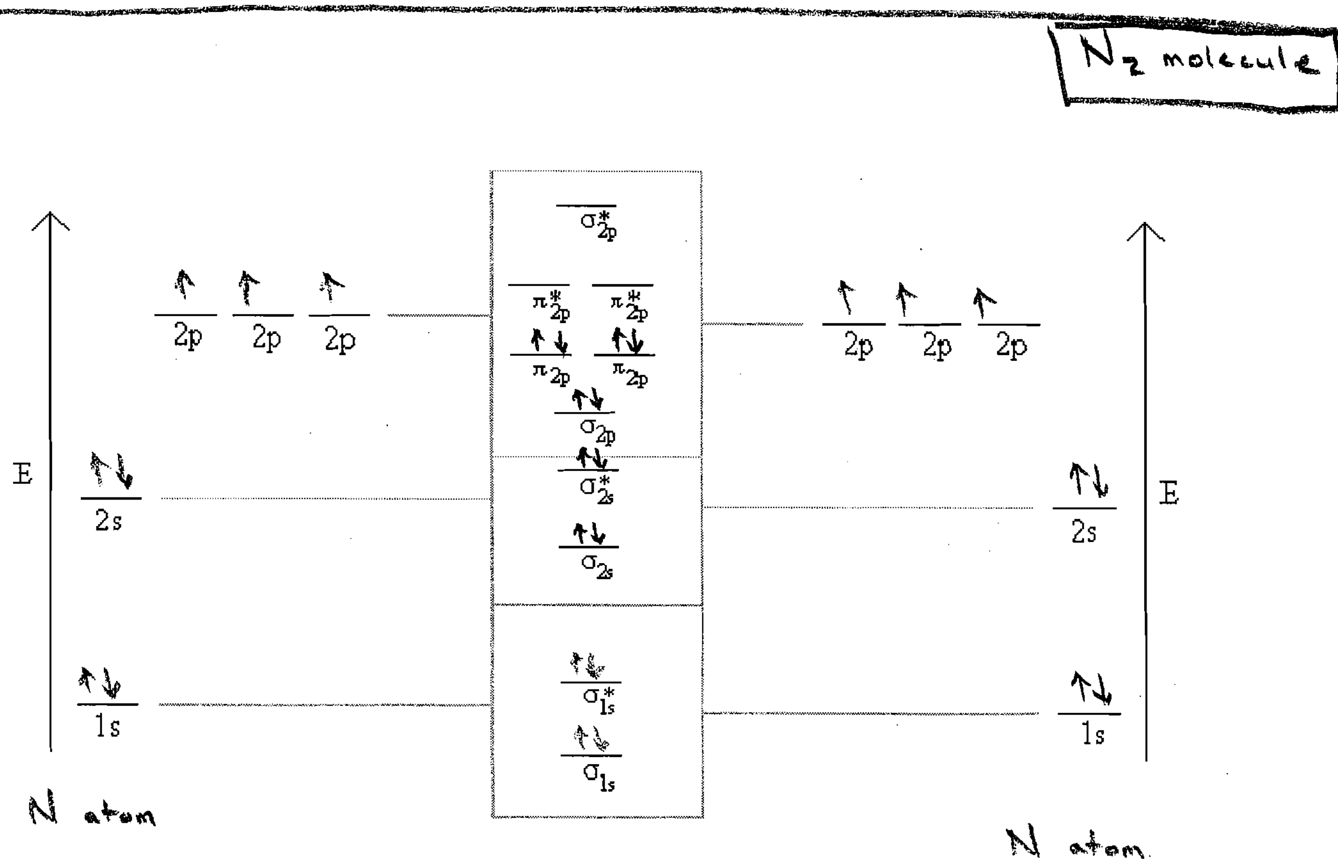

All e^- are paired — diamagnetic

Please read each exam question carefully. Terms such as *correct, false, unpaired, pairs, H-C-F bond angle, H-C-H angle, greatest, and smallest are* used.

Unit 1 (Material Assessed on Exam 1)

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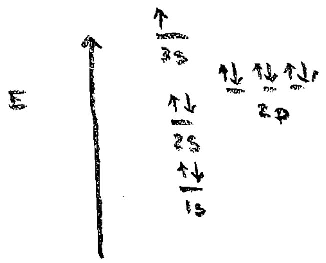
1. The ground-state electron configuration of a sodium atom is:

(A) $1s^22s^22p^63s^1$
(B) $1s^22s^22p^6$
(C) $1s^22s^22p^63p^1$
(D) $1s^22s^22p^4$
(E) $1s^22s^23s^3$

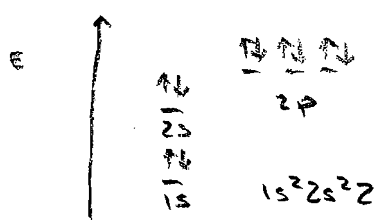


11 Na

$1s^22s^22p^63s^1$

2. The ground-state electron configuration of oxide (O^{2-}) is:

(A) $1s^22s^22p^63s^1$
(B) $1s^22s^22p^6$
(C) $1s^22s^22p^63p^1$
(D) $1s^22s^22p^4$
(E) $1s^22s^23s^3$



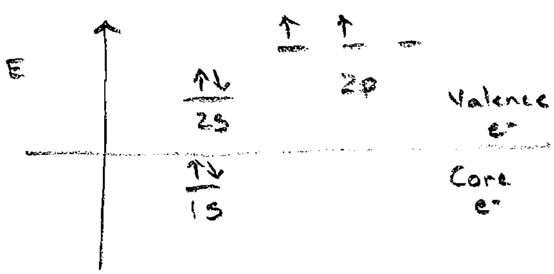
$1s^22s^22p^6$

8 O

8+2=10 e⁻

3. How many valence electrons are present in an carbon atom?

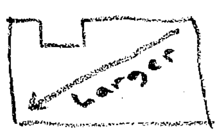
(A) 0.
(B) 2.
(C) 4.
(D) 6.
(E) 8.



6 C

4. Consider F, S, Ge, Sr, and O. The atom with the **smallest** atomic size is:

(A) F
(B) S
(C) Ge
(D) Sr
(E) O



5. Consider Ca^{2+}, Ca, Br^-, and Br. Which of the following two statements is **correct**?

(A) Ca^{2+} is smaller than Ca.
(B) Br^- is smaller than Br.

Ca^{2+} has two fewer e⁻ than Ca

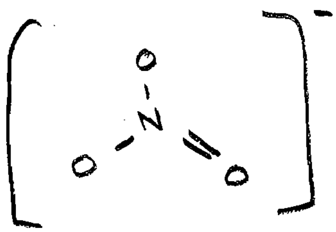
Br^- has one greater e⁻ than Br

6. The Lewis Dot Structure of PH_3 depicts:

(A) There are no lone **pairs** of electrons.
(B) There is one lone **pair** of electrons.
(C) There are two lone **pairs** of electrons.
(D) There are three lone **pairs** of electrons.
(E) There are four lone **pairs** of electrons.

7. The nitrogen-oxygen bond order in nitrate ion (NO_3^-) is:

(A) 1.00.
(B) 1.33.
(C) 1.50.
(D) 1.75.
(E) 2.00.

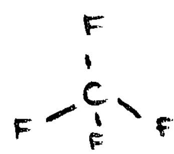


one resonance form shows 4 bonds in 3 locations

$\frac{4}{3}$ or $1\frac{1}{3}$ or 1.33

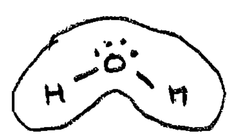
8. The bond angle in CF_4 is: ↖ Tetrahedral

(A) 180°.
(B) 120°.
(C) 109.5°.
(D) A little greater than 109.5°.
(E) A little less than 109.5°.



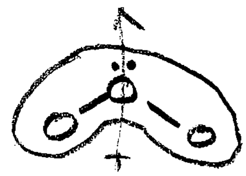
9. The molecular geometry of water is:

(A) bent.
(B) trigonal planar.
(C) trigonal pyramidal.
(D) tetrahedral.
(E) octahedral.

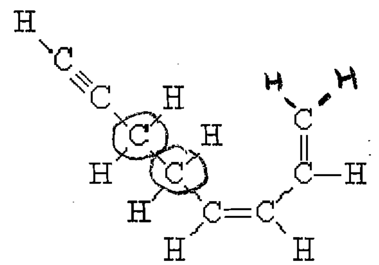


10. Consider O_2, O_3, CO_2, CH_4, and CF_4. Which of the following statements is **correct**?

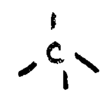
(A) O_2 is a **polar molecule**.
(B) O_3 is a **polar molecule**.
(C) CO_2 is a **polar molecule**.
(D) CH_4 is a **polar molecule**.
(E) CF_4 is a **polar molecule**.



11. Consider the molecule below and identify the **correct** statement.



sp^3



(A) There is one carbon that has an sp^3 hybridization scheme.
(B) There are two carbons that have sp^3 hybridization schemes.
(C) There are three carbons that have sp^3 hybridization schemes.
(D) There are four carbons that have sp^3 hybridization schemes.
(E) There are six carbons that have sp^3 hybridization schemes.

12. Molecular orbital theory predicts the F_2^- ion (a minus one charge) has:

(A) no unpaired electrons.
(B) one unpaired electrons.
(C) two unpaired electrons.
(D) three unpaired electrons.
(E) six unpaired electrons.

See MO on Page 3 above – it shows the complete scheme

13. Consider MO (Molecular Orbital Theory). The N_2 molecule is:

(A) diamagnetic
(B) paramagnetic
(C) trimagnetic
(D) tetramagnetic
(E) hexamagnetic

See MO on Page 3 above – it shows the complete scheme

Unit 2 (Material Assessed on Exam 2)

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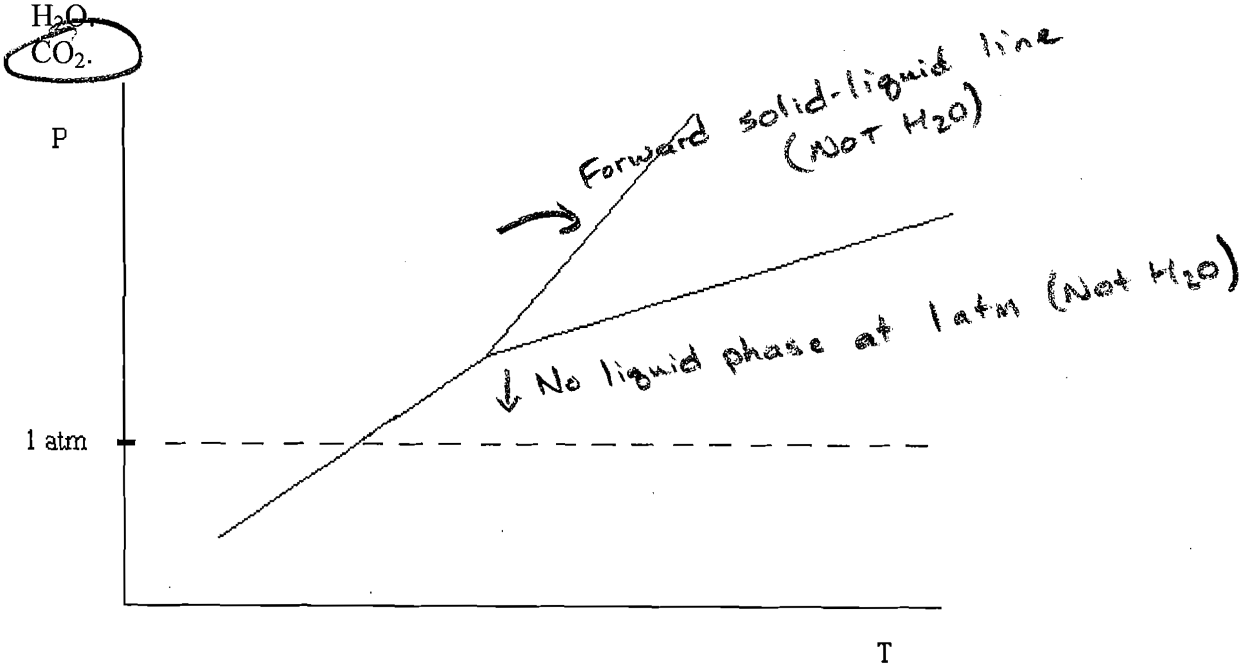
14. The phase diagram below is for:

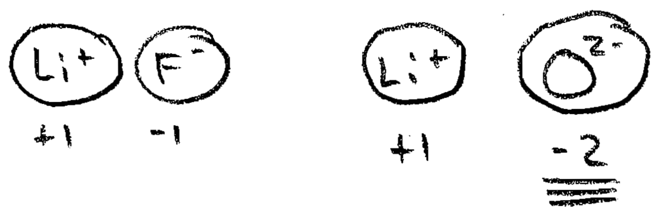
(A) H_2O.
(B) CO_2.



LiF Li2O

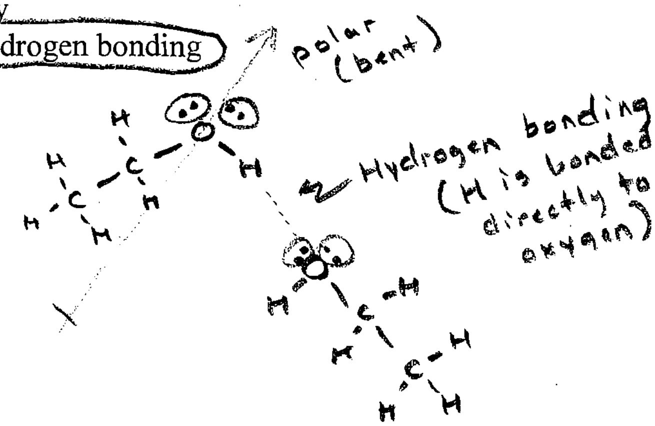
15. Lithium fluoride melts at 848 °C. Lithium oxide melts at 1570 °C. The difference in melting points can be attributed to:

(A) Different intermolecular forces (dispersion, dipole-dipole, hydrogen bonding)
(B) Different ionic charges (+ and -)
(C) Different distances between nuclei (d)
(D) The sheet-like structure
(E) Network covalent compounds



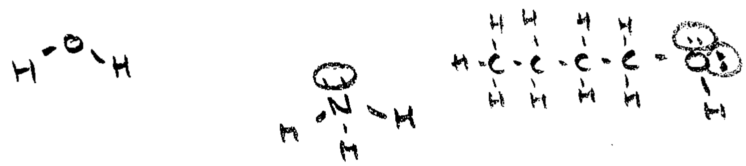
16. Consider the alcohol CH_3CH_2OH [please take a moment to draw the correct structure]. The intermolecular forces present in CH_3CH_2OH are:

(A) Dispersion forces only
(B) Dispersion forces and dipole-dipole forces only
(C) Dispersion forces, dipole-dipole forces, and hydrogen bonding
(D) Hydrogen bonding only
(E) Network covalent

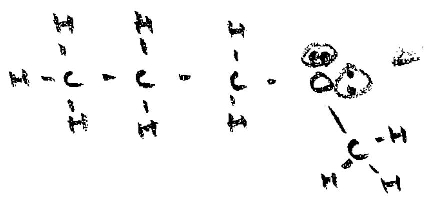


17. Consider H_2O, NH_3, $CH_3CH_2CH_2CH_2OH$, and $CH_3CH_2CH_2OCH_3$. Which of these **does not** exhibit hydrogen bonding?

(A) H_2O
(B) NH_3
(C) $CH_3CH_2CH_2CH_2OH$
(D) $CH_3CH_2CH_2OCH_3$



This molecule does not have H bonded to O, N, F, or S



18. The equivalent number of atoms in the SC unit cell is:

(A) 1 $8 \times \frac{1}{8} = 1$
(B) 2
(C) 3
(D) 4
(E) 1/8

19. A student ( ) obtains a 0.500 m aqueous solution of $AlCl_3$. The freezing point of his solution is:

$i = 4$ (Al^{3+}, Cl^-, Cl^-, Cl^-)

(A) -2.79 °C.
(B) +2.79 °C.
(C) +5.58 °C.
(D) -5.58 °C.
(E) -3.72 °C.

$\Delta T_f = i\, m\, k_f$

$\Delta T_f = (4)(0.500\ m)(1.86\ \frac{°C}{m}) = 3.72°C$

$T_f = 0°C - 3.72°C = -3.72°C$

20. A student ( ) dissolves 12.000 g of an unknown polymer in 800 mL of water at 320 K. He measures the osmotic pressure to be 0.0677 mm Hg. What is the molar mass of the polymer?

(A) 2.71 x 10^6 g/mol
(B) 4.42 x 10^6 g/mol
(C) 1.73 x 10^5 g/mol
(D) 1.73 x 10^6 g/mol
(E) 2.26 x 10^6 g/mol

$\pi V = nRT$

$n = \frac{\pi V}{RT} = \frac{\left(\frac{0.0677\ mmHg}{760\ \frac{mmHg}{atm}}\right)(0.800\ L)}{(0.0821\ \frac{L \cdot atm}{mol \cdot K})(320\ K)} = 2.713 \times 10^{-6}\ mol$

Molar Mass $= \frac{g}{mol} = \frac{12.000\ g}{2.713 \times 10^{-6}\ mol} = 4423940.\ g/mol$

$= 4.42 \times 10^6\ g/mol$

21. A student places 1.200 moles of sodium chloride into 750 g of water. The molality of the solution is:

(A) 0.667 m
(B) 1.50 m
(C) 27.4 m
(D) 0.625 m
(E) 1.60 m

$m = \frac{mol}{kg} = \frac{1.200\ mol}{0.750\ kg} = 1.60\ m$

22. A student () obtains a 500.0 gram sample of ^{14}C ($t_{1/2}$ = 5730 years). How long will it take so that only 125.0 grams of ^{14}C remain?

(A) 5730 years
(B) 1730 years
(C) 125.0 years
(D) 22920 years
(E) 11460 years

500 g $\xrightarrow{t_{1/2}}$ 250 g $\xrightarrow{t_{1/2}}$ 125 g

5730 y   5730 y   = 11460 y

23. A student () obtains a 500.0 gram sample of ^{14}C ($t_{1/2}$ = 5730 years). How long will it take so that only 475.0 grams of ^{14}C remain?

(A) 424 years
(B) 5444 years
(C) 6032 years
(D) 287 years
(E) 6.20×10^{-6} years

① Calc k

$\ln \frac{1}{2} = -k(5730\,y)$

$k = 1.2097 \times 10^{-4}\ \frac{1}{y}$

② Calc t

$\ln \left[\frac{A}{A_0} \right] = -kt$

$\ln \left(\frac{475.0\,g}{500.0\,g} \right) = -(1.2097 \times 10^{-4}\ \frac{1}{y})(t)$

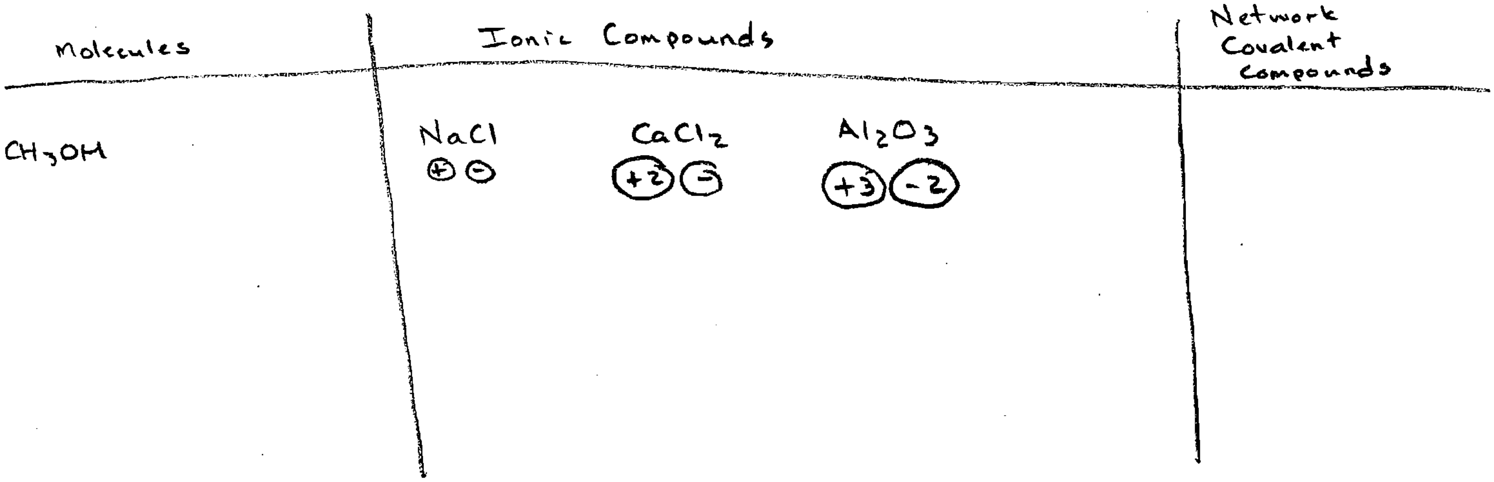
$-0.05129 = -(1.2097 \times 10^{-4}\ \frac{1}{y})(t)$

$t = 424\ y$

24. Consider calcium chloride, aluminum oxide, methanol (CH_3OH), and sodium chloride. Arranged in decreasing melting point, these are:

Lowest mp ... **Highest mp**

(A) sodium chloride < aluminum oxide < methanol < calcium chloride.
(B) aluminum oxide < methanol < calcium chloride < sodium chloride.
(C) calcium chloride < aluminum oxide < sodium chloride < methanol.
(D) sodium chloride < calcium chloride < aluminum oxide < methanol.
(E) methanol < sodium chloride < calcium chloride < aluminum oxide.



Unit 3 (Material Discussed after Exam 2)

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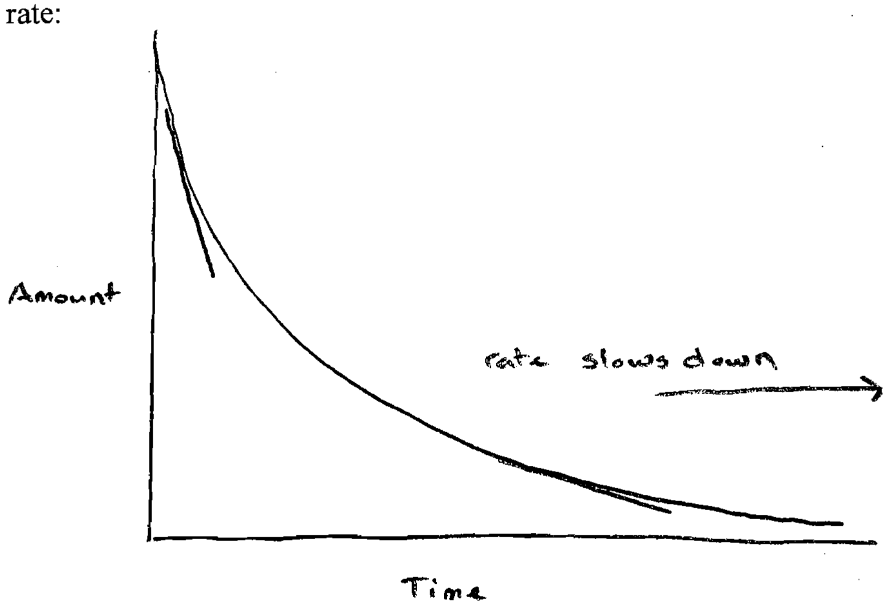
25. As the reaction proceeds, the rate:

(A) increases.
(B) decreases.
(C) remains constant.



26. The rate expression for the reaction: $2\ CuS\ (s) + 3\ O_2\ (g) \rightarrow 2\ CuO\ (s) + 2\ SO_2\ (g)$ is:

(A) $\text{Rate} = -2\frac{\Delta[CuS]}{\Delta t} = -3\frac{\Delta[O_2]}{\Delta t} = +2\frac{\Delta[CuO]}{\Delta t} = +2\frac{\Delta[SO_2]}{\Delta t}$

(B) $\text{Rate} = -\frac{\Delta[CuS]}{\Delta t} = -\frac{\Delta[O_2]}{\Delta t} = +\frac{\Delta[CuO]}{\Delta t} = +\frac{\Delta[SO_2]}{\Delta t}$

(C) $\text{Rate} = -[CuS] = -[O_2] = +[CuO] = +[SO_2]$

(D) $\text{Rate} = -2[CuS] = -3[O_2] = +2[CuO] = +2[SO_2]$

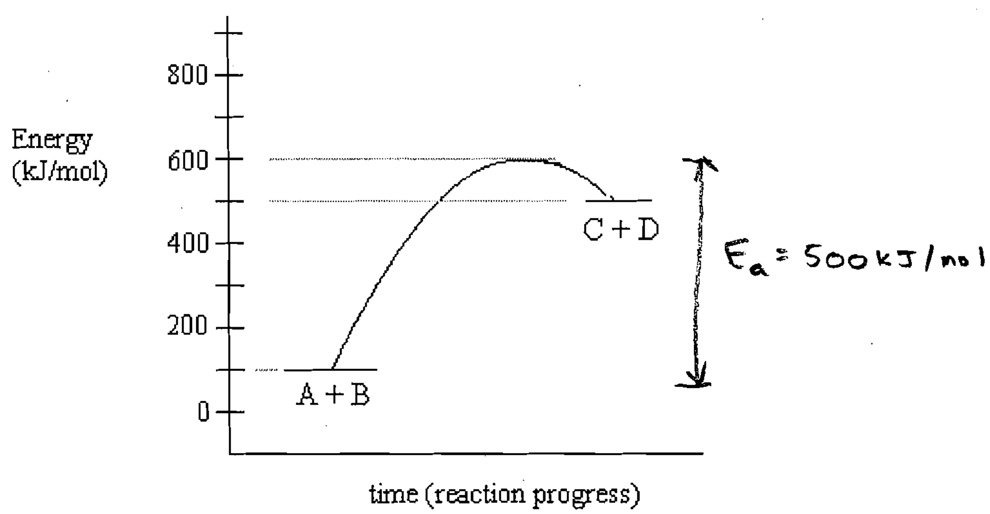
(E) $\text{Rate} = -\left(\frac{1}{2}\right)\frac{\Delta[CuS]}{\Delta t} = -\left(\frac{1}{3}\right)\frac{\Delta[O_2]}{\Delta t} = +\left(\frac{1}{2}\right)\frac{\Delta[CuO]}{\Delta t} = +\left(\frac{1}{2}\right)\frac{\Delta[SO_2]}{\Delta t}$

27. Which of the following is **false**?

(A) Increasing the temperature of a reaction will increase the rate. ✓
(B) Increasing the number of collisions will increase the rate of reaction. ✓
(C) Lowering the activation energy will increase the rate of reaction. ✓
(D) An enzyme decreases the rate of a process. Increases!
(E) A catalyst lowers the activation energy of a process. ✓

28. Based on the thermodynamic data plotted below, the activation energy (E_a) for the reaction $A + B \rightarrow C + D$ is:

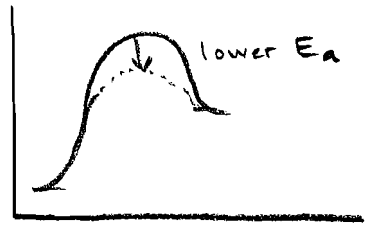
(A) +100 kJ/mol
(B) +400 kJ/mol
(C) +500 kJ/mol
(D) +600 kJ/mol



29. Which of the following **does not** increase the rate of the reaction $A + B \rightarrow C$ where Rate = $k[A]^2[B]^2$?

(A) an increase in A.
(B) an increase in [A].
(C) an increase in [B].
(D) an increase in E_a.
(E) an increase in T.

$k = Ae^{\frac{-E_a}{RT}}$ ← lower E_a!



30. The following are initial rate data for: **A + 2 B → C + 2 D**

Experiment	Initial [A]	Initial [B]	Initial Rate
1	0.10	0.10	0.300
2	0.20	0.10	0.600
3	0.10	0.20	1.200

(A) The rate law is Rate = $k[A]^1[B]^2$.
(B) The rate law is Rate = $k[A]^0[B]^2$.
(C) The rate law is Rate = $k[A]^2[B]^0$.
(D) The rate law is Rate = $k[A]^2[B]^1$.
(E) The rate law is Rate = $k[A]^1[B]^1$.

Double [A] → Rate Doubles

$[A]^1$

Double [B] → Rate Quadruples

$[B]^2$

Rate = $k[A]^1[B]^2$

31. The following reaction was allowed to come to equilibrium at 300 K. Calculate K_c.

$$4\ FeCl_3(s) + 3\ O_2(g) \Leftrightarrow 2\ Fe_2O_3(s) + 6\ Cl_2(g)$$

The equilibrium concentrations were analyzed and found to be:

$[O_2] = 3.34$ M and $[Cl_2] = 2.07$ M

(A) $K_c =$ [redacted] 2.11
(B) $K_c = 0.238$
(C) $K_c = 1.36$
(D) $K_c = 0.795$
(E) $K_c = 1.43$

$K = \frac{\text{products}}{\text{reactants}} = \frac{[Cl_2]^6}{[O_2]^3} = \frac{(2.07)^6}{(3.34)^3} = \frac{78.67}{37.26} = 2.11$

32. The following reaction is at equilibrium:

$$2HBr\ (g) \Leftrightarrow H_2\ (g) + Br_2\ (g) \qquad \Delta H^\circ = +72\ \text{kJ (endothermic)}$$

(A) The concentration of Br_2 (g) increases when HBr (g) is added. shift to the right when more reactant is added
(B) The concentration of Br_2 (g) decreases when HBr (g) is added.
(C) The concentration of Br_2 (g) stays the same when HBr (g) is added.

33. The following reaction is at equilibrium:

$$2HBr\,(g) \Leftrightarrow H_2\,(g) + Br_2\,(g) \qquad \Delta H^\circ = +72\text{ kJ (endothermic)}$$

(A) The concentration of HBr (g) increases when the system is heated.
(B) The concentration of HBr (g) decreases when the system is heated.
(C) The concentration of HBr (g) stays the same when the system is heated.

Heat drives an endothermic process to the right – the reaction needs heat to go to the right and you are providing the heat.

34. Consider the system $SO_2(g) + CO_2(g) \Leftrightarrow CO(g) + SO_3(g)$ $K_c = 6.76$

A student prepares the system and measures:

$[SO_2] = 1.03$ M $[CO_2] = 1.22$ M $[CO] = 2.93$ M $[SO_3] = 2.90$ M

(A) The system is at equilibrium.
(B) The system is not at equilibrium.

$$Q = \frac{\text{products}}{\text{reactants}} = \frac{[CO][SO_3]}{[SO_2][CO_2]} = \frac{(2.93)(2.90)}{(1.03)(1.22)} = 6.76$$

$Q = K$

35. The pH of 0.925 M HCl (aq) is:

(A) 1.00.
(B) 1.05.
(C) 0.0339.
(D) 0.925.
(E) 2.10.

$HCl \xrightarrow{100\%} H^+ + Cl^-$

∅ ↑ 0.925 M

$pH = -\log[H^+] = -\log(0.925\text{ M}) = \underline{0.0339}$

36. The pH of 0.925 M CH_3COOH (aq) is:

(A) 2.90.
(B) 2.39.
(C) 1.45.
(D) 0.925.
(E) 4.78.

	CH_3COOH ⇄	CH_3COO^- +	H^+
I	0.925	0	0
C	−x	+x	+x
E	0.925 −x	x	x

$K_a = 1.8 \times 10^{-5} = \frac{[CH_3COO^-][H^+]}{[CH_3COOH]} = \frac{(x)(x)}{0.925 - x} = \frac{x^2}{0.925}$

$1.8 \times 10^{-5} = \frac{x^2}{0.925}$ $x^2 = (1.8 \times 10^{-5})(0.925) = 1.665 \times 10^{-5}$

$x = [H^+] = \sqrt{1.665 \times 10^{-5}} = 0.0041$

$pH = -\log[H^+] = -\log(0.0041) = 2.90$

37. Well, well, well... CH 122 is over. Now it's time to:

(A) Take CH 122 again because it was so rewarding and fun.
(B) Sleep until April.
(C) Party—but just a little. Must save energy for Spring Break.
(D) Two words: Twinkies and TextMessaging.
(E) Spend some time thinking about those things 19 year olds think of… ~~sex~~, ~~parties~~, ~~friends~~, ~~music~~, ~~reality TV~~, ~~food~~, mutual funds, retirement plans, taking out the trash early, golf, effective denture cleaners, and insurance.

- **[Any response will receive full credit; even no response.]**
- **Questions 1 through 36 have four points attached (144 total). Any responses to Question 37 will receive full credit (6 Points total); even no responses.**
- **The point total for this exam is 150 points. See the grade sheet or CH 122 web syllabus for grade computation details.**
- **Final exam keys, scores, and course grades will be posted on the CH 122 website as they become available.**