Chemistry 122 — Winter 2007 — Oregon State University

Final Exam — March 19, 2007 — Dr. Richard Nafshun

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.

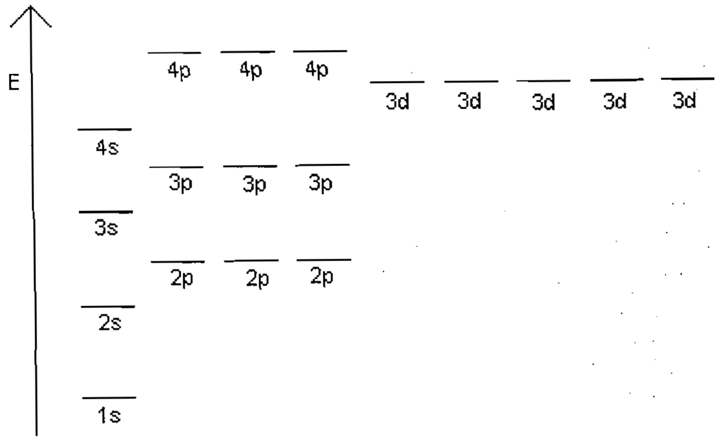
Fill in the front page of the Scantron answer sheet with your last name, first name, middle initial, and student identification number. **Leave the class section number and the test form number blank.**

This exam consists of 37 multiple-choice questions. Each question has four points associated with it (Question 37 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 in the appropriate stack and present your University ID Card to the proctor. 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 x 10^{-5}

1 H Hydrogen 1.0079																	2 He Helium 4.0026
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984	10 Ne Neon 20.179
11 Na Sodium 22.98977	12 Mg Magnesium 24.305											13 Al Aluminum 26.9815	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.08	21 Sc Scandium 44.9559	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.996	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.70	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.22	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium 98.906	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.30
55 Cs Cesium 132.9054	56 Ba Barium 137.33	57–71 *Rare earths	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium 226.0254	89–103 †Actinides	104 Rf Rutherfordium (261)	105 Ha Hahnium (262)	106 Sg Seaborgium (263)	107 Ns Neilsbohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 ‡ (269)	111 ‡			114				

57 La Lanthanium 138.9055	58 Ce Cerium 140.12	59 Pr Praseodymium 140.9077	60 Nd Neodymium 144.24	61 Pm Promethium 145	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
89 Ac Actinium 227.0278	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359	92 U Uranium 238.029	93 Np Neptunium 237.0482	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (254)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium 259	103 Lr Lawrencium 262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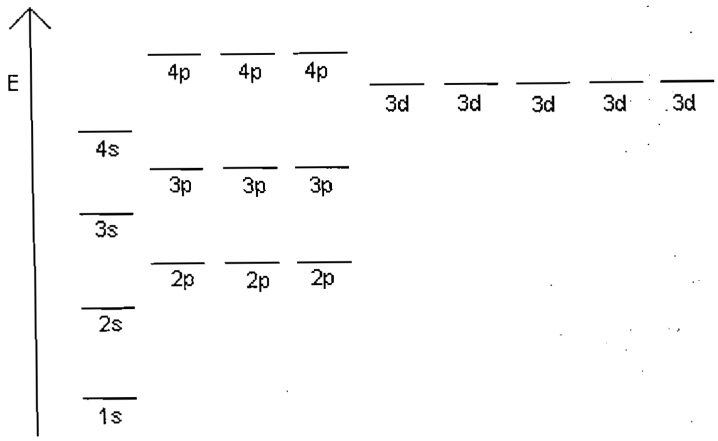
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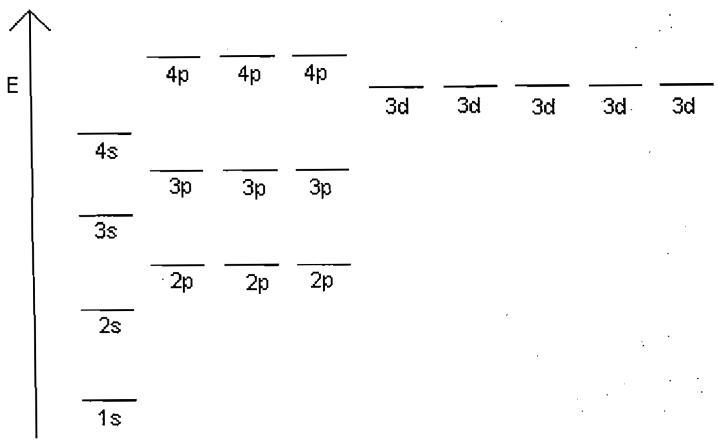
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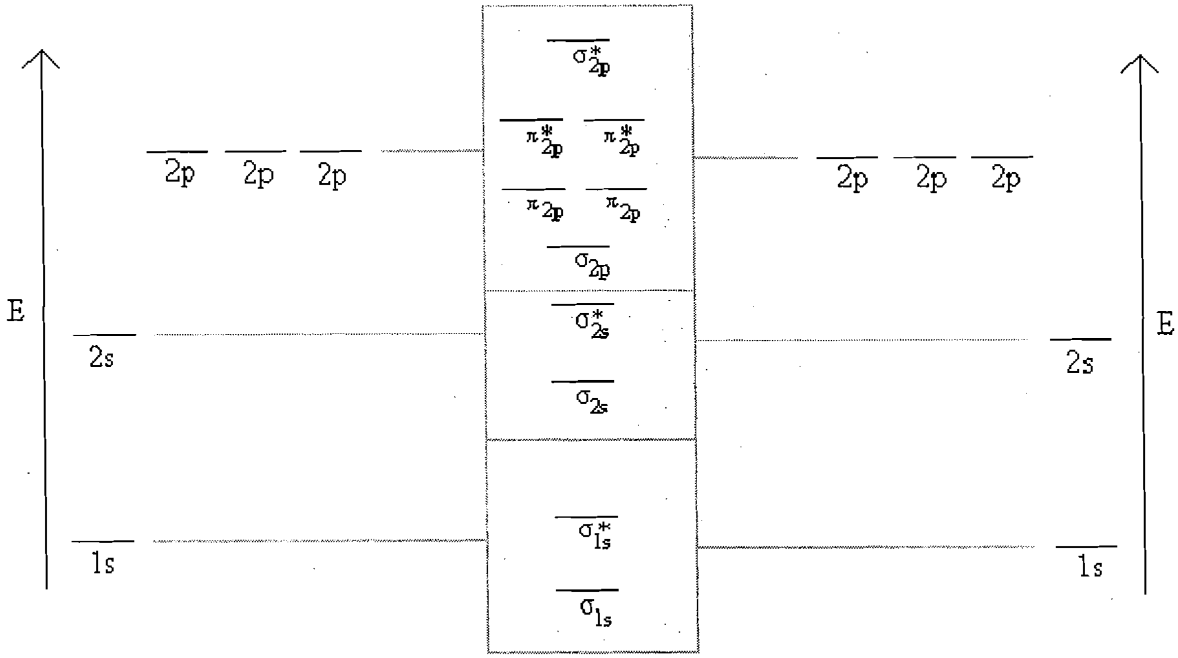
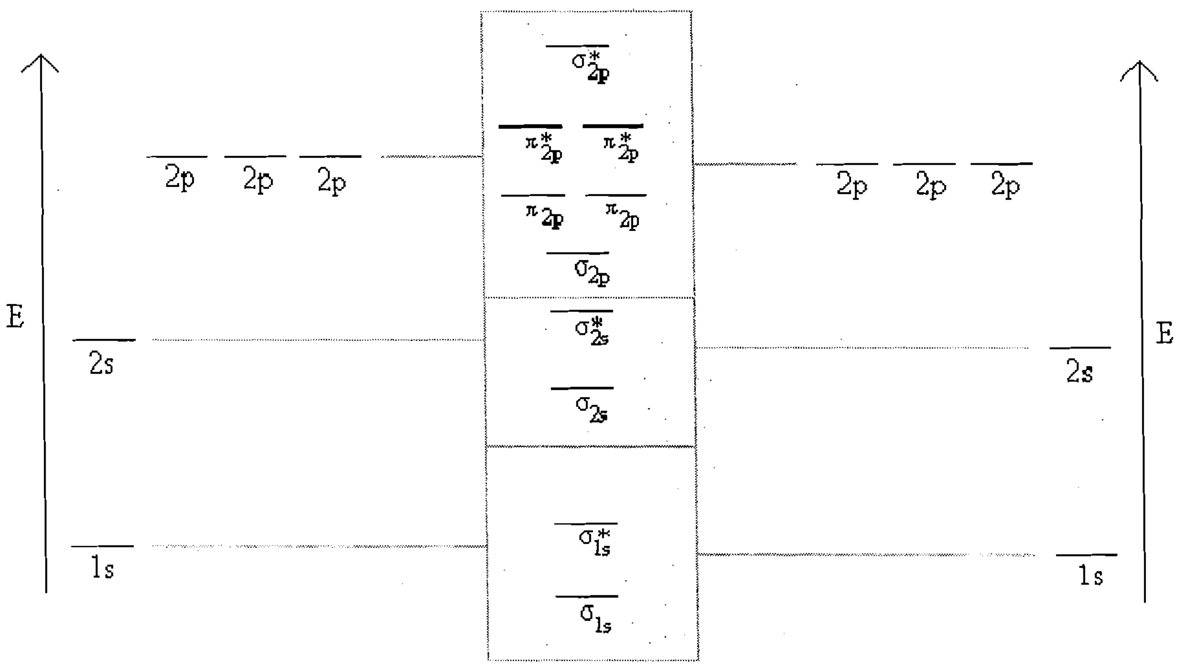


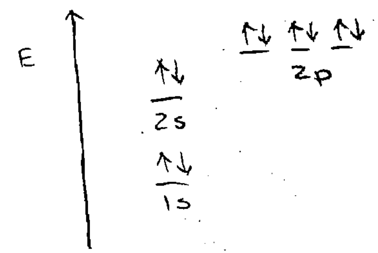


Please read each exam question carefully. Terms such as *correct, false, unpaired, pairs, H-C-F bond angle, H-C-H angle, greatest, and smallest are* used.

Unit 1 Material (First assessed on Exam 1)

1. There are ___ **unpaired** electrons in a ground-state nitride (N^{3-}) ion.

   (A) 0
   (B) 1
   (C) 2
   (D) 3
   (E) 4

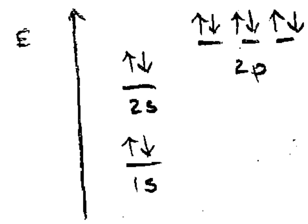


$N - 7e^-$

$N^{3-} - 10e^-$

2. The ground-state electron configuration of a fluoride ion (F^-) is:

   (A) $1s^22s^23s^23p^2$
   (B) $1s^22s^23s^1$
   (C) $1s^22s^22p^4$
   (D) $1s^22s^22p^63s^23p^2$
   (E) $1s^22s^22p^6$



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

3. Consider Al^{3+}, Al, F^-, and F. Which of the following statements is correct?

   (A) Al^{3+} is smaller than Al
   (B) F^- is smaller than F

Al^{3+} has three fewer e^- than Al

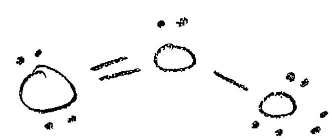
F^- has one more e^- than F

4. 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

5. The oxygen-oxygen bond order in ozone (O_3) is:

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

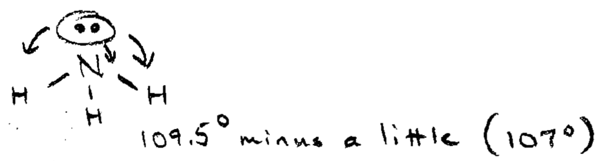


$3 \times 6 = 18\ e^-$ system

$\frac{3 \text{ bonds}}{2 \text{ locations}} = 1.5$

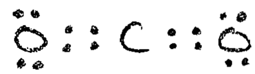
6. The H-N-H bond angle in ammonia (NH_3) is:

(A) 90°
(B) 120°
(C) 109.5°
(D) A little greater than 109.5°
(E) A little less than 109.5°



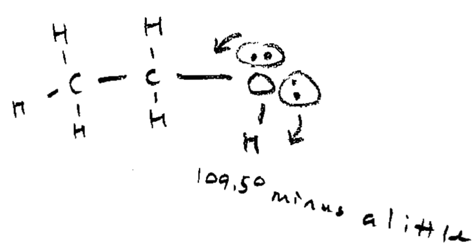
7. The oxygen-carbon-oxygen bond angle in CO_2 is:

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



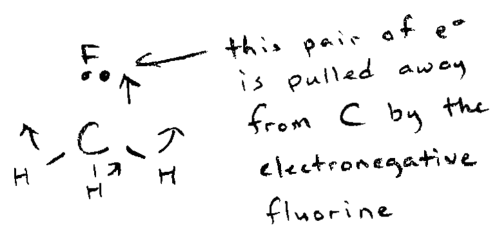
8. The C-O-H bond angle in ethanol, CH_3CH_2OH, is:

(A) 90°
(B) 120°
(C) 109.5°
(D) A little greater than 109.5°
(E) A little less than 109.5°



9. The H-C-H bond angle in monofluoromethane (CH_3F) is a little greater than 109.5°. This deviation from the ideal bond angle of 109.5° can be attributed to:

(A) Lone pairs of electrons on carbon
(B) The electronegativity of fluorine
(C) Hydrogen bonding
(D) Sublimation
(E) Global warming



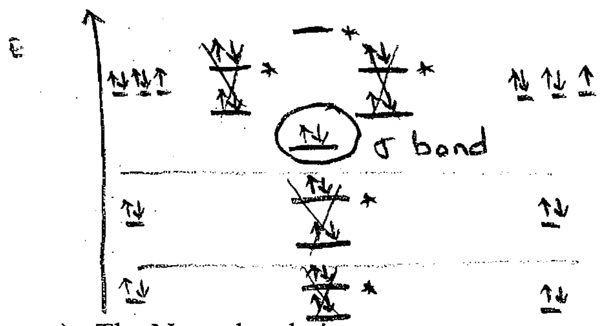
10. Consider ethyne, C_2H_2. Draw the structure of ethyne. Ethyne contains:

(A) no π-bonds.
(B) one π-bond.
(C) two π-bonds.
(D) three π-bonds.

H−C≡C−H (σ π π)

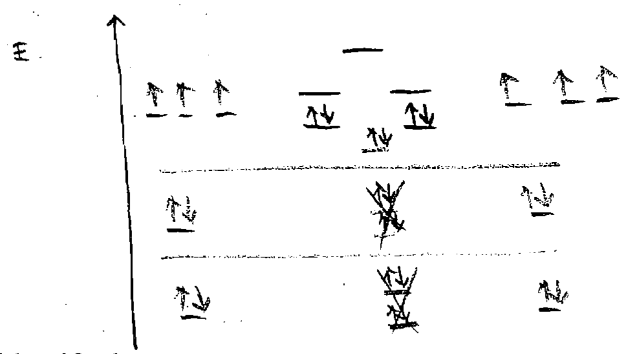
11. Molecular orbital theory predicts the O_2^{2-} ion (a minus two charge) has a bond order of:

(A) 0.5
(B) 1.0
(C) 1.5
(D) 2.0
(E) 2.5



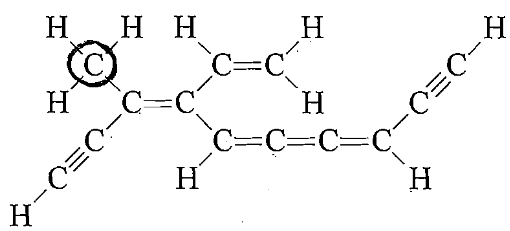
12. Consider MO (Molecular Orbital Theory). The N_2 molecule is:

(A) paramagnetic
(B) diamagnetic
(C) magma-magnetic
(D) Spiderman-magnetic
(E) Casino Royale-magnetic



→ All e⁻ are paired

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



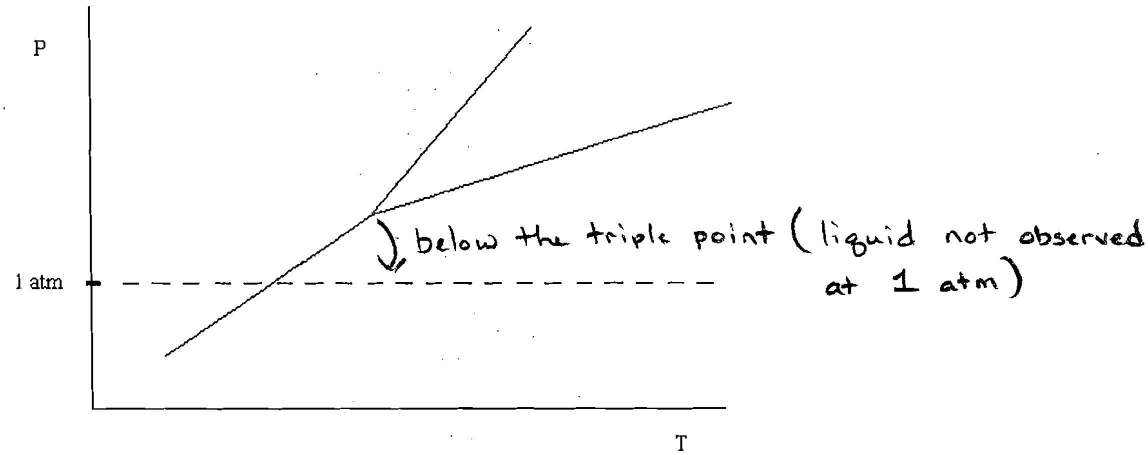
sp³ (four σ bonds)

(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 four carbons that have sp^3 hybridization schemes.
(D) There are eight carbons that have sp^3 hybridization schemes.
(E) There are thirteen carbons that have sp^3 hybridization schemes.

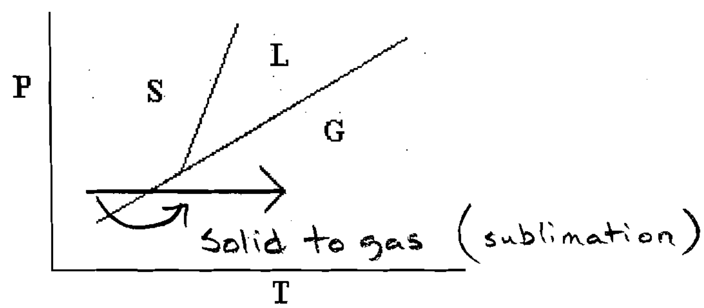
Unit 2 Material (First assessed on Exam 2)

14. The phase diagram below is for:

(A) H_2O
(B) CO_2



15. Consider the phase diagram below.



The transition indicated by the arrow is:

(A) Melting
(B) Boiling
(C) Sublimation
(D) Deposition
(E) Freezing

molecule (non-metals)

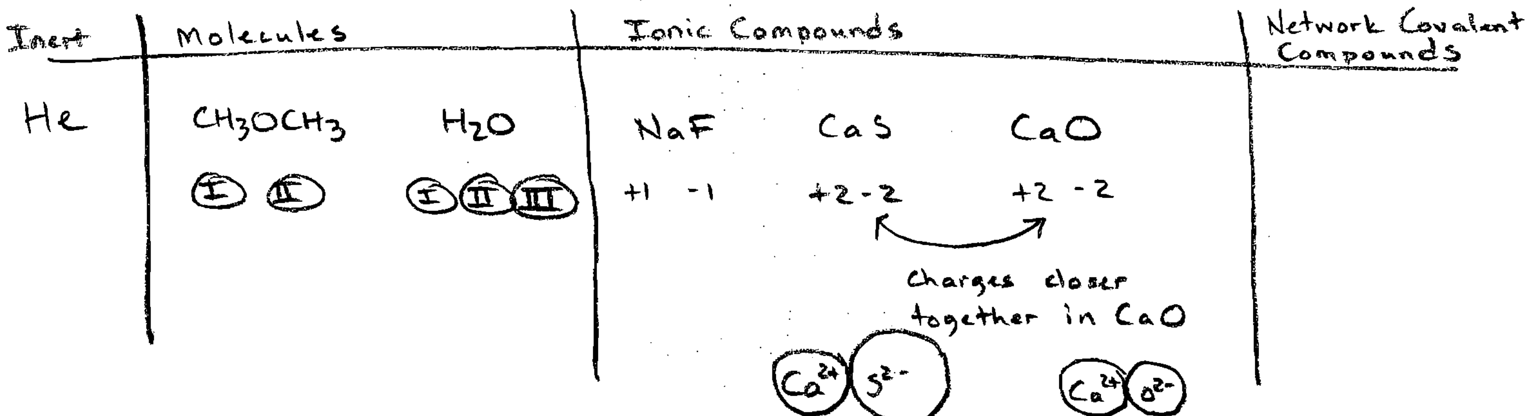
16. Ethane, CH_3CH_3, melts at -172 °C. Li_2O melts at 1570 °C. The difference in melting points can be attributed to: ionic compound (metal and non-metal)

(A) Different intermolecular forces (dispersion, dipole-dipole, hydrogen bonding)
(B) Different ionic charges
(C) Different distances between nuclei (d)
(D) Network covalent compounds
(E) One is a molecule (attractions by intermolecular forces), one is an ionic compound (attractions by charges)

17. Consider NaF, CaO, H_2O, CaS, He, and CH_3OCH_3. Arranged in **increasing** melting point, these are:

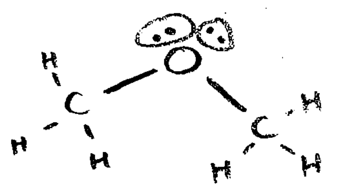
Lowest mp **Highest mp**

(A) NaF < CaO < CaS < He < CH_3OCH_3 < H_2O
(B) He < NaF < CaO < CaS < CH_3OCH_3 < H_2O
(C) He < CH_3OCH_3 < H_2O < NaF < CaO < CaS.
(D) He < CH_3OCH_3 < H_2O < NaF < CaS < CaO.
(E) He < NaF < CaS < CaO < CH_3OCH_3 < H_2O



18. Consider CH_3OCH_3. The intermolecular forces present in CH_3OCH_3 are:

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



bent (dipole-dipole)

19. The product produced from the diol and dicarboxylic acid shown below is:

Two hands

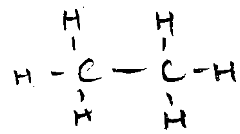
$$HOCH_2OH + HOC(=O)CH_2CH_2CH_2C(=O)OH \rightarrow$$

Two hands

(A) An ionic solid
(B) A polymer
(C) A network covalent compound
(D) Quartz
(E) Soap

20. Which of the following compounds **cannot** undergo free radical polymerization?

(A) C_2H_4
(B) C_2H_6 ← no π-bond
(C) C_2F_4
(D) C_2Cl_4
(E) C_2F_2

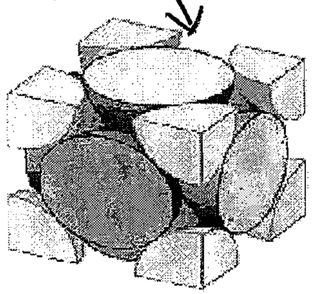


21. The equivalent number of atoms in the FCC unit cell is:

(A) 1
(B) 2
(C) 3
(D) 4
(E) 6

$8 \times \frac{1}{8} = 1$
$+\ 6 \times \frac{1}{2} = 3$
4

22. The structure below [from *Worksheet 6 During Recitation*] represents:



(A) An SC unit cell
(B) A BCC unit cell
(C) A FCC unit cell
(D) A NCAA unit cell
(E) An OSU unit cell

23. The freezing point of 0.150 m aqueous $CaCl_2$ is:

↖ 3 pieces

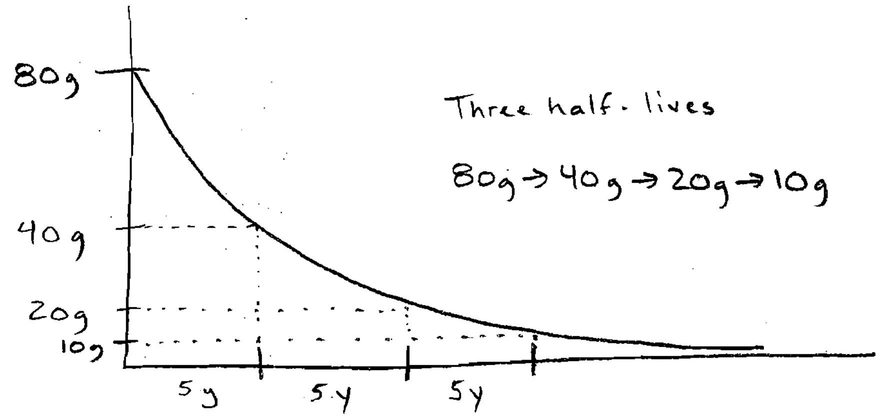
(A) - 0.279 °C
(B) - 4.19 °C
(C) - 0.558 °C
(D) + 100.279 °C
(E) - 0.837 °C

$\Delta T_f = i\,m\,k_f = (3)(0.150\,m)(1.86\ \frac{°C}{m}) = 0.837\ °C$

$T_f = 0°C - 0.837°C = -0.837°C$

24. A student ( ) obtains an 80.0 gram sample of ^{60}Co ($t_{1/2}$ = 5.0 years). How many grams of ^{60}Co will remain after 15.0 years?

(A) 16.0 grams
(B) 8.0 grams
(C) 5.33 grams
(D) 10.0 grams
(E) 20.0 grams



25. A student ( ) obtains an 80.0 gram sample of ^{60}Co ($t_{1/2}$ = 5.0 years). How long will it take so that only 50.0 grams of ^{60}Co remain?

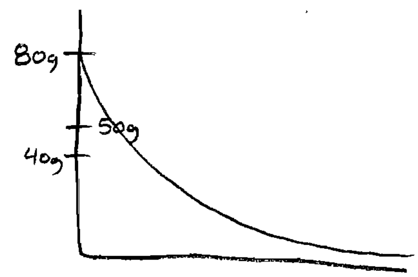
(A) 30.0 years
(B) 50.0 years
(C) 10.0 years
(D) 3.39 years
(E) 0.625 years

① Calc k $\ln \frac{1}{2} = -k(5.0y)$ $k = 0.1386 \frac{1}{y}$

② Calc t $\ln \frac{50g}{80g} = -(0.1386 \frac{1}{y})(t)$

$-0.470 = -(0.1386 \frac{1}{y})(t)$

$t = 3.39y$



26. 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	0.222
2	0.20	0.10	0.888
3	0.10	0.20	0.222

x2 x2 x4 x0 ← $[A]^2$ ← $[B]^0$

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

Rate = $k[A]^2[B]^0$

Unit 3 Material (Not previously assessed)

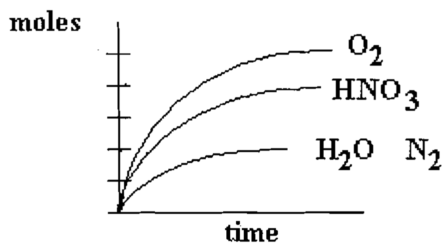
27. As the reaction proceeds, the rate:

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

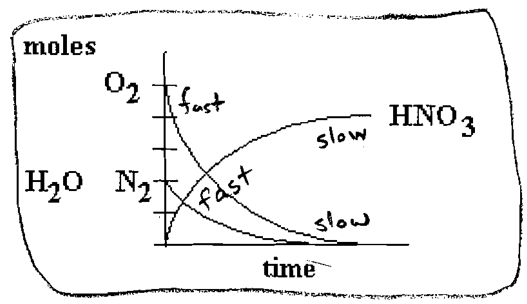
slows down (less reactant present as time goes on)

28. Which graph could correctly depict the changes in concentrations for the reaction $2\ N_2\ (g) + 5\ O_2\ (g) + 2\ H_2O\ (l) \rightarrow 4\ HNO_3\ (aq)$?

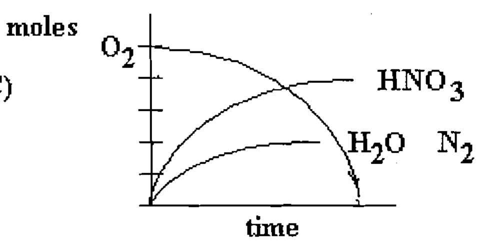
(A)



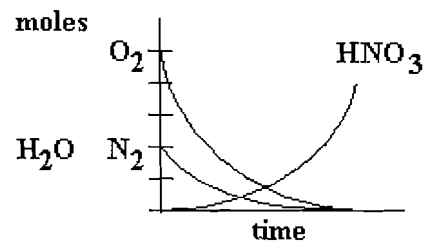
(B)



(C)



(D)



29. Which of the following statements 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) The addition of a catalyst will decrease the rate of a process. The catalyst will INCREASE the rate (the rock you used in lab)
(E) The addition of a catalyst will lower the activation energy of a process.

30. The equilibrium law expression for the reaction $2\ NO_2(g) \Leftrightarrow O_2(g) + 2\ NO\ (g)$ is:

($[NO_2]^2$ reactants; $[O_2]$ $[NO]^2$ products)

(A) $K_c = \frac{[O_2][NO]}{[NO_2]^2}$

(B) $K_c = \frac{[O_2]^2[NO]}{[NO_2]^2}$

(C) $K_c = \frac{[O_2][NO]^2}{[NO_2]^2}$

(D) $K_c = \frac{[O_2][NO]}{[NO_2]}$

(E) $K_c = \frac{[NO_2]^2}{[O_2][NO]^2}$

31. 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.

$K_c(\text{for experiment}) = \frac{[CO][SO_3]}{[SO_2][CO_2]} = \frac{(2.93)(2.90)}{(1.03)(1.22)} = 6.76$

K_c (for experiment) = K_c (literature) ∴ the system is at equilibrium

32. The following reaction is at equilibrium:

$2HBr\ (g) \Leftrightarrow H_2\ (g) + Br_2\ (g)$ $\Delta H^o = +72$ 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.

The process is endothermic (heat will drive the reaction to the right)

33. The following reaction is at equilibrium:

$2HBr\ (g) \Leftrightarrow H_2\ (g) + Br_2\ (g)$ $\Delta H^o = +72$ kJ (endothermic)

(A) The concentration of Br_2 (g) increases when HBr (g) 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.

34. The pH of 0.050 M HCl (aq) is:

(A) 1.30.
(B) 0.050.
(C) 0.100.
(D) 1.70.
(E) 3.00.

$HCl \xrightarrow{100\%} H^+ + Cl^-$ (Strong Acid) OR $HCl(aq) + H_2O(l) \xrightarrow{100\%} H_3O^+(aq) + Cl^-(aq)$ (Strong Acid)

~~0.050M~~ 0.050M 0.050M ~~0.050M~~ 0.050M 0.050M

$pH = -\log[H_3O^+]$ OR $pH = -\log[H^+]$

$pH = -\log(0.050) = 1.30$

35. A student obtains 0.175 M CH_3COOH (aq). The "ICE" table used to solve the equilibrium expression for this weak acid is:

(A)

	CH_3COOH (aq)	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq)	H_3O^+ (aq)
I	0		0.175	0.175
C	+x		+x	+x
E	x		0.175+x	0.175+x

(B)

	CH_3COOH (aq)	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq)	H_3O^+ (aq)
I	0		0	0
C	-x		+x/2	+x/2
E	-x		x	x

(C)

	CH_3COOH (aq)	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq)	H_3O^+ (aq)
I	0.175		0	0
C	-x		+x/2	+x/2
E	0.175-x		x/2	x/2

(D)

	CH_3COOH (aq)	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq)	H_3O^+ (aq)
I	0.175		0	0
C	-x		+x	+x
E	0.175-x		x	x

(E)

	CH_3COOH (aq)	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq)	H_3O^+ (aq)
I	0.175		0.175	0.175
C	-x		+x	+x
E	0.175-x		0.175+x	0.175+x

	CH_3COOH (aq) +	H_2O (l) $\rightleftarrows$	CH_3COO^- (aq) +	H_3O^+ (aq)
Initial	0.175	X	0	0
Change	− x		+ x	+x
Equilibrium	0.175 - x		x	x

Some CH_3COOH goes away

Make CH_3COO^- and H_3O^+

36. CH_3COOH (aq) is a weak acid ($K_a = 1.80 \times 10^{-5}$). The pH of 0.175 M CH_3COOH (aq) is:

(A) 0.175
(B) 3.15×10^{-6}
(C) 2.75
(D) 5.50
(E) 0.150

	$CH_3COOH(aq)$ +	$H_2O(l)$ ⇄	$CH_3COO^-(aq)$ +	$H_3O^+(aq)$
I	0.175	X	0	0
C	−x		+x	+x
E	0.175		x	x

$K_a = 1.80 \times 10^{-5} = \frac{\text{products}}{\text{reactants}} = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]} = \frac{x^2}{0.175 - \cancel{x}}$ out

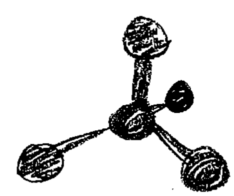
$1.80 \times 10^{-5} = \frac{x^2}{0.175}$

$x^2 = 3.15 \times 10^{-6}$

$x = 0.00177 = [H_3O^+]$

$pH = -\log[H_3O^+] = -\log(0.00177) = 2.75$

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



(A) Participate in organized social gatherings. I'm headed to one right now.
(B) Drive hundreds of miles from here to find a sunny day.
(C) Check out the new Home Depot. I hear they have molecule-patterned wallpaper in stock.
(D) Brush my teeth and change out of my pajamas.
(E) Two words: March Madness.

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