Chemistry 122
Final Exam

Winter 2005
March 16, 2005

Oregon State University
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
$k_f (H_2O) = 1.86$ °C/m

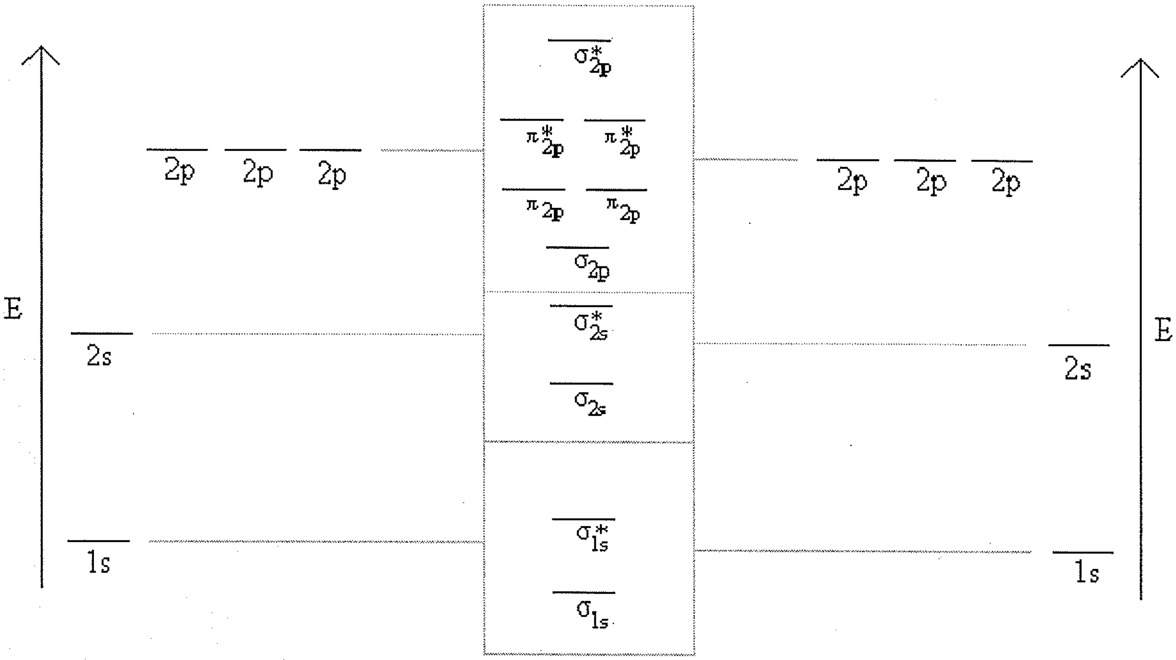
m = mol/kg
$K_a (CH_3COOH) = 1.8 \times 10^{-5}$

760 mm Hg = 760 torr = 1 atm
M = mol/L

$$k = Ae^{\frac{-Ea}{RT}}$$

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VII			1B	IIB	IIIA	IVA	VA	VIA	VIIA	VIIIA
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				

→ Stable region?


E
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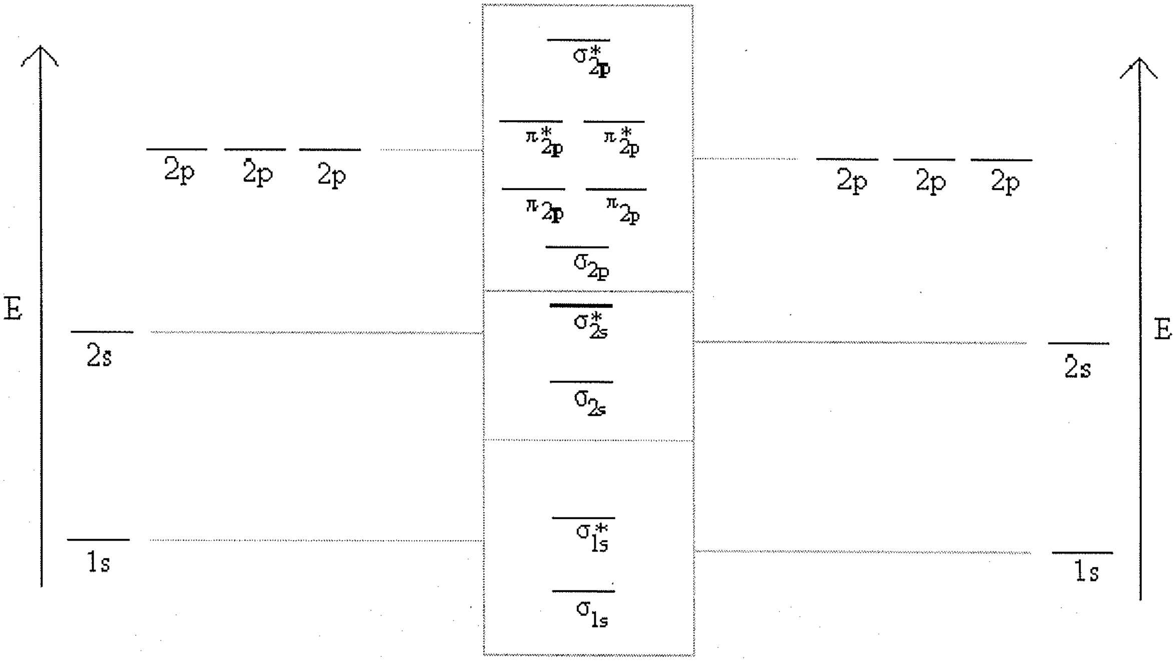
E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σ*2s
σ2s
σ*1s
σ1s
2p
2p
2p
2s
1s
E

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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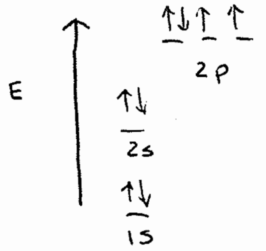
1. The ground-state electron configuration of an oxygen atom is:

(A) $1s^22s^23s^23p^1$.
(B) $1s^22s^23s^1$.
[✓ (C) $1s^22s^22p^4$.]
(D) $1s^22s^22p^3$.
(E) $1s^22s^23s^3$.



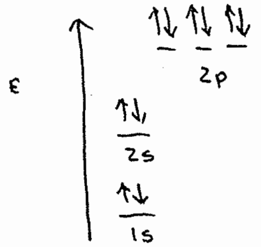
$1s^22s^22p^4$

8
O

8 electrons

2. The ground-state electron configuration of a sodium ion (Na^+) 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) $1s^22s^22p^6$.]



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

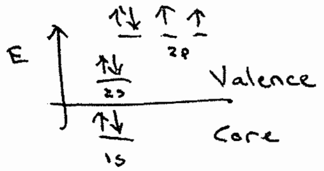
11
Na

11 - 1 = 10 electrons

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

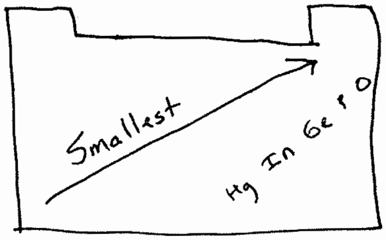
(A) 0.
(B) 2.
(C) 4.
[✓ (D) 6.]
(E) 8.

$1s^2|2s^22p^4$



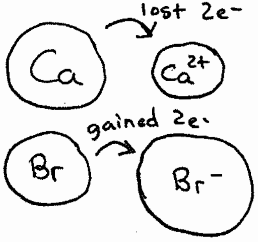
4. Consider Hg, In, Ge, P, and O. The atom with the **smallest** atomic size is:

(A) Hg.
(B) In.
(C) Ge.
(D) P.
[✓ (E) O.]



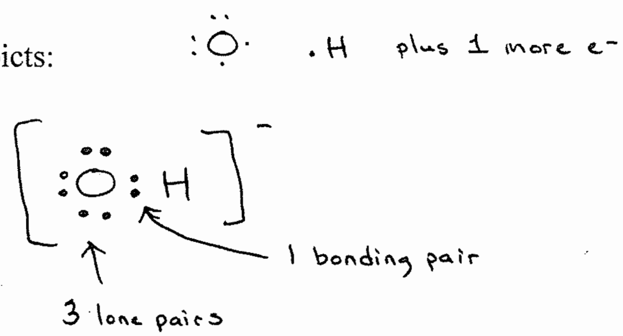
5. Consider Ca^{2+}, Ca, Br^-, and Br. Which of the following statements is **correct**?

(A) Ca^{2+} is larger than Ca.
[✓ (B) Br^- is larger than Br.]



6. The Lewis Dot Structure of the hydroxide ion (OH^-) 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 oxygen-oxygen bond order in ozone (O_3) is:

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

18 electron system

$$\text{Bond Order} = \frac{\text{number bonds}}{\text{number locations}} = \frac{3}{2} = 1\tfrac{1}{2} \text{ or } 1.5$$

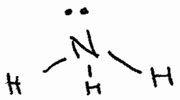
8. The bond angle in water is:

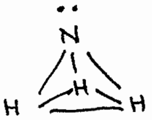
(A) 180°.
(B) 120°.
(C) 109.5°.
(D) A little greater than 109.5°.
(E) [✓ A little less than 109.5°.]

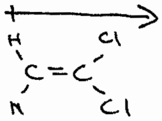
109.5° minus a little

9. The molecular geometry of NH_3 is:

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

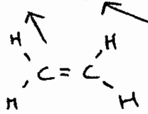


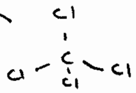




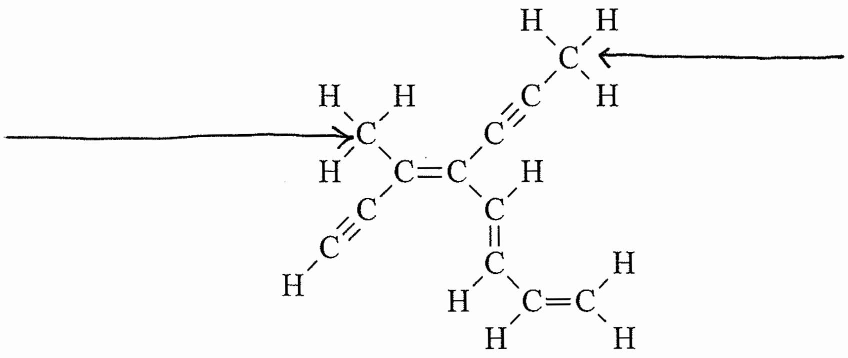
10. Consider CH_2CCl_2, CH_2CH_2, SF_6, CO_3^{2-}, and CCl_4. Which is a polar?

(A) [✓ CH_2CCl_2.]
(B) CH_2CH_2.
(C) SF_6.
(D) CO_3^{2-}.
(E) CCl_4.



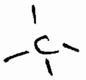


11. Consider the molecule below and identify the **correct** statement.



(A) [✓ There are two carbons that have sp^3 hybridization schemes.]
(B) There are three carbons that have sp^3 hybridization schemes.
(C) There are four carbons that have sp^3 hybridization schemes.
(D) There are five carbons that have sp^3 hybridization schemes.
(E) There are six carbons that have sp^3 hybridization schemes.

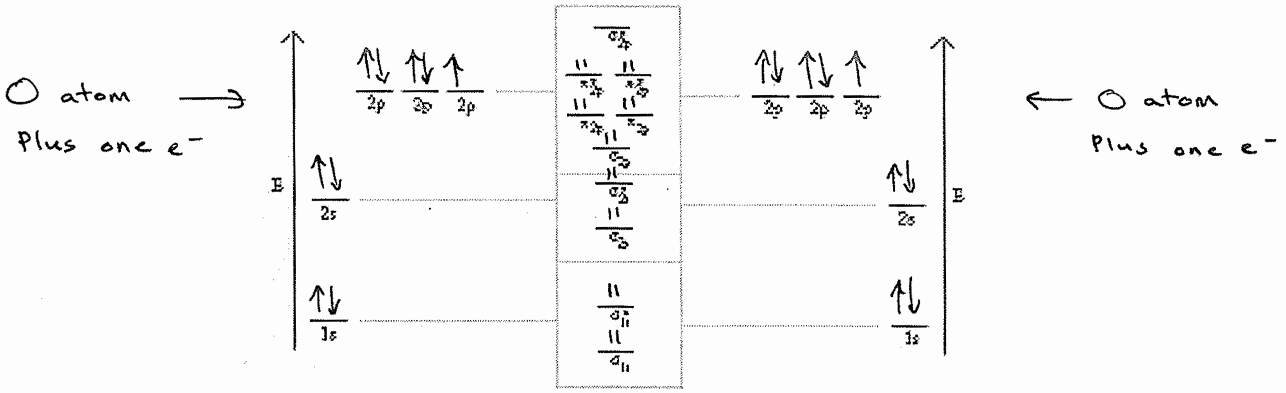
sp^3 carbon



four single bonds

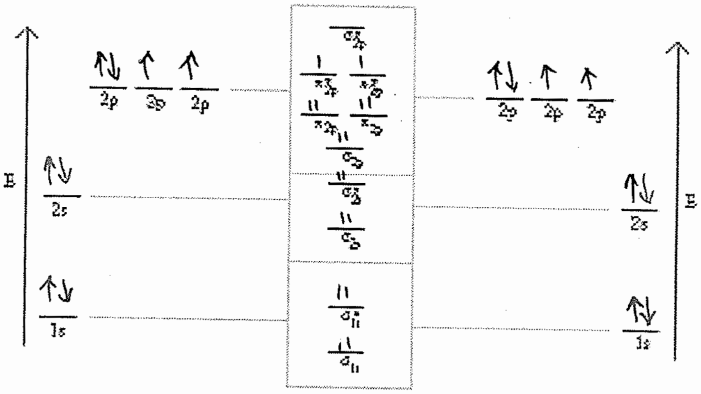
12. Molecular orbital theory predicts the O_2^{2-} ion (a minus two charge) has:

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



13. Consider MO (Molecular Orbital Theory). The O_2 molecule is:

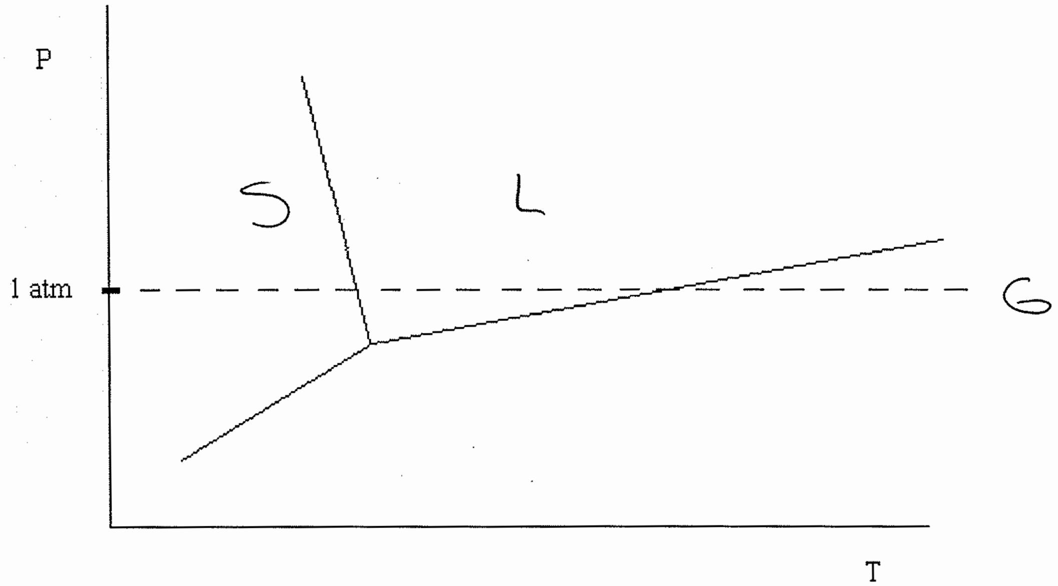
(A) diamagnetic. ← all e⁻ are paired
(B) [✓ paramagnetic.] → at least one unpaired electron
(C) springmagnetic.
(D) monty-python-magnetic.
(E) martha-stewart-magnetic



Unit 2

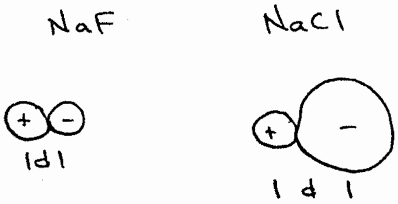
14. The phase diagram below is for:

(A) [✓ H_2O.] At 1atm we observe solid, liquid, and gas
(B) CO_2.



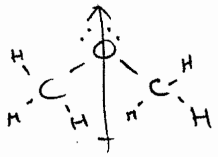
15. Sodium fluoride melts at 993 °C. Sodium chloride melts at 801 °C. The difference in melting points can be attributed to:

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



16. Consider the ether CH_3OCH_3 [please take a moment to draw the correct structure]. 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.
(E) network covalent.

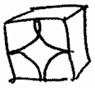


Bent – dipole-dipole forces

Note: No H-Bonding – the hydrogens are all bonded to C, not O.

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

(A) [✓ 1.]
(B) 2.
(C) 3.
(D) 4.
(E) 1/8.



$8 \times \frac{1}{8} = 1$

18. The freezing point of 0.800 m aqueous NaCl is: ← $i = 2$ Na^+ Cl^-

(A) - 1.49 °C.
(B) - 1.60 °C.
(C) - 0.027 °C.
(D) - 4.46 °C.
(E) [✓ - 2.98 °C.]

$\Delta T_f = i\ m\ k_f = (2)(0.800\ m)(1.86\ \frac{°C}{m})$

$= 2.98°C$

$T_f = 0°C - 2.98°C = -2.98°C$

19. A student dissolves 12.000 g of an unknown polymer in 800 mL of water at 320 K. She 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.

Molar Mass = $\frac{g}{mol}$

mol ⇒ $\pi V = nRT$

$$n = \frac{\pi V}{RT} = \frac{\left[\frac{0.0677\ \cancel{mmHg}}{\left(\frac{760\ \cancel{mmHg}}{1\ atm}\right)}\right](0.800\ \cancel{L})}{\left(0.0821\ \frac{\cancel{L}\cdot atm}{mol\cdot \cancel{K}}\right)(320\ \cancel{K})}$$

$= 2.71 \times 10^{-6}$ mol

$$\text{Molar Mass} = \frac{12.000g}{2.71\times10^{-6}\ mol} =$$

4.42×10^{6} g/mol

20. Which of the following sets of compounds are expected to be soluble in carbon tetrachloride, CCl_4? ← Non-polar

[✓ (A) CO_2, C_8H_{18}, C_4H_{10}]
(B) H_2O, CH_4, CH_3OCH_3
(C) NaCl, CH_3CH_2OH, NH_3
(D) CH_3CH_2OH, NH_3, C_4H_{10}

21. A student places 50.00 grams of sodium chloride into 750 g of water. The molality of the solution is:

$$m = \frac{\text{moles solute}}{\text{kg solvent}} = \frac{50.00g\left(\frac{1\ mol}{58.45\ g}\right)}{0.750\ kg} = 1.14\ m$$

(A) 0.667 m
(B) 1.50 m
[✓ (C) 1.14 m]
(D) 0.0667 m
(E) 1.56 m

NaCl = 58.45 g/mol

22. A student () obtains a 100.0 gram sample of ^{14}C ($t_{1/2}$ = 5730 years). How long will it take so that only 75.0 grams of ^{14}C remain?

(A) 2865 years
[✓ (B) 2378 years]
(C) 1433 years
(D) 4298 years
(E) 2680 years

Step 1: Calc k $\ln\frac{1}{2} = -kt_{1/2}$

$-0.6931 = -(k)(5730\,y)$

$k = 1.21\times10^{-4}\ \frac{1}{y}$

Step 2: Calc t $\ln\left[\frac{75\,g}{100\,g}\right] = -(1.21\times10^{-4}\ \frac{1}{y})(t)$

$t = 2378\,y$

23. Compounds with relatively high vapor pressure have:

(A) high boiling points and weak intermolecular forces
[✓ (B) low boiling points and weak intermolecular forces]
(C) high boiling points and strong intermolecular forces
(D) low boiling points and strong intermolecular forces

low bp – this is due to weak intermolecular forces

24. Consider CH_3OCH_3, sodium fluoride, water, calcium oxide, and neon. Arranged in **increasing** melting point, these are:

Lowest mp **Highest mp**

(A) neon < CH_3OCH_3 < water < calcium oxide < sodium fluoride.
(B) neon < sodium fluoride < CH_3OCH_3 < water < calcium oxide.
(C) neon < sodium fluoride < CH_3OCH_3 < calcium oxide < water.
[✓ (D) neon < CH_3OCH_3 < water < sodium fluoride < calcium oxide.]
(E) CH_3OCH_3 < calcium oxide < water < neon < sodium fluoride.

Molecules & Atoms			Ionic Compounds	
Ne	CH_3OCH_3	H_2O	NaF	CaO
(I)	(I) (II)	(I) (II) (III)	+1 -1	+2 -2

25. As the reaction proceeds, the rate:

(A) increases.
(B) [✓ decreases.]
(C) remains constant.

The rate decreases are reactants decrease

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

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

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

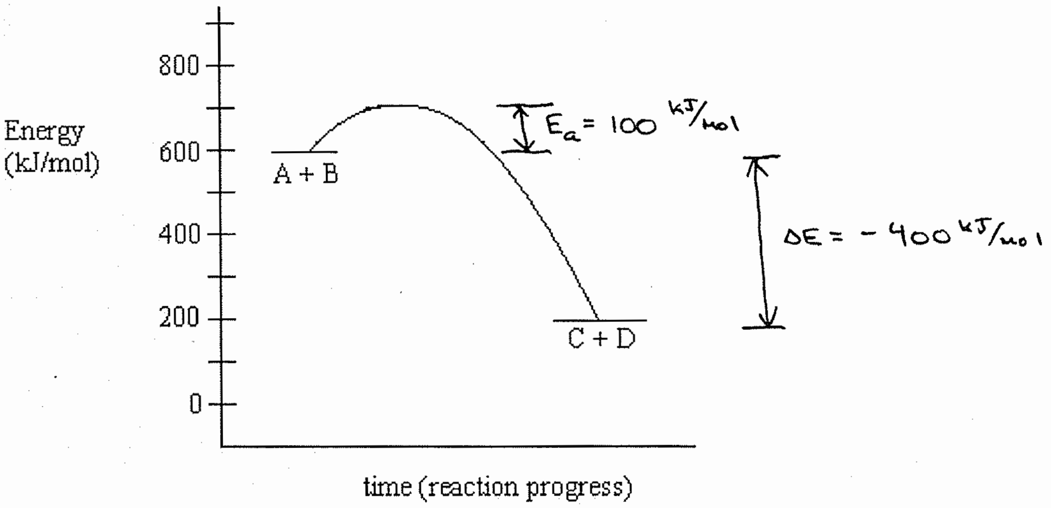
(C) Rate = -[CuS]= -[O_2] = +[CuO] = +[SO_2]

(D) Rate = -2[CuS] = -3[O_2] = +2[CuO] = +2[SO_2]

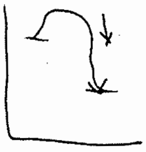
(E) [✓ Rate = $-\left(\dfrac{1}{2}\right)\dfrac{\Delta[CuS]}{\Delta t} = -\left(\dfrac{1}{3}\right)\dfrac{\Delta[O_2]}{\Delta t} = +\left(\dfrac{1}{2}\right)\dfrac{\Delta[CuO]}{\Delta t} = +\left(\dfrac{1}{2}\right)\dfrac{\Delta[SO_2]}{\Delta t}$]

27. Based on the thermodynamic data plotted below, the activation energy (E_a) and the change in energy (ΔE) for the reaction A + B → C + D are:

(A) the activation energy (E_a) is +100 kJ/mol and the change in energy (ΔE) is -500 kJ/mol.
(B) [✓ the activation energy (E_a) is +100 kJ/mol and the change in energy (ΔE) is -400 kJ/mol.]
(C) the activation energy (E_a) is +500 kJ/mol and the change in energy (ΔE) is -100 kJ/mol.
(D) the activation energy (E_a) is +400 kJ/mol and the change in energy (ΔE) is -100 kJ/mol.
(E) the activation energy (E_a) is +400 kJ/mol and the change in energy (ΔE) is +100 kJ/mol.



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



A decrease in E_a would increase the rate — not an increase in E_a.

$K = Ae^{-\frac{E_a}{RT}}$

(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.

29. 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	0.10	0.20	0.222
3	0.20	0.10	0.888

(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 = $k[A]^1[B]^1$.

Look at experiments 1 & 3:
[B] is constant; [A] is doubled; rate quadruples
$[A]^2$

Look at experiments 1 & 2:
[A] is constant; [B] is doubled; rate unchanged
$[B]^0$

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

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

$2\ CuS(s) + 3\ O_2(g) \Leftrightarrow 2\ CuO(s) + 2\ SO_2(g)$

The equilibrium concentrations were analyzed and found to be:

$[O_2] = 3.34$ M and $[SO_2] = 2.07$ M

(A) $K_c = 0.620$.
(B) [✓ $K_c = 0.115$.]
(C) $K_c = 1.36$.
(D) $K_c = 0.795$.
(E) $K_c = 1.43$.

$$K_c = \frac{[SO_2]^2}{[O_2]^3} = \frac{(2.07)^2}{(3.34)^3} = 0.115$$

31. The following reaction is at equilibrium:

$2\ N_2O_4\ (g) + O_2\ (g) \Leftrightarrow 2\ N_2O_5\ (g) \qquad \Delta H^\circ = +127\ \text{kJ}$

↙ Endothermic – heat is needed for the reaction to proceed. By heating you are producing more product.

(A) [✓ The concentration of N_2O_5 (g) increases when the system is heated.]
(B) The concentration of N_2O_5 (g) decreases when the system is heated.
(C) The concentration of N_2O_5 (g) stays the same when the system is heated.

32. The following reaction is at equilibrium:

$\overset{\uparrow}{2\ N_2O_4}\ (g) + \overset{\downarrow}{O_2}\ (g) \overset{\longrightarrow}{\Leftrightarrow} 2\ N_2O_5\ (g) \qquad \Delta H^\circ = +127\ \text{kJ}$

(A) The ~~concentration of O_2 (g) increases when N_2O_4 (g) is added.~~
(B) [✓ The concentration of O_2 (g) decreases when N_2O_4 (g) is added.]
(C) The concentration of O_2 (g) stays the same when N_2O_4 (g) is added.

When N_2O_4 is added, more N_2O_5 is produced.
This requires O_2.

33. The following reactants were combined in a 1.0 L reaction vessel at 447 K:

$SO_2\ (g) + SF_6\ (g) \Leftrightarrow 2\ SOF_3\ (g) \qquad K_c = 4.05$

After a short period, the concentrations of reactants and products were found to be as follows:

$[SO_2] = 0.296\ M,\ [SF_6] = 2.70\ M,\ [SOF_3] = 2.13\ M.$

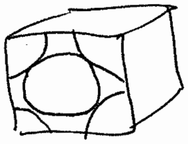
(A) The system is at equilibrium.
(B) The system is not at equilibrium and more SOF_3 (g) will be formed.
(C) [✓ The system is not at equilibrium and more SO_2 (g) and SF_6 (g) will be formed.]

$$Q = \frac{[SOF_3]^2}{[SO_2][SF_6]} = \frac{(2.13)^2}{(0.296)(2.70)} = 5.68$$

$Q > K$ more SO_2 & SF_6 will be formed

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

(A) 1/8.
(B) ½.
(C) 1.
(D) 2.
(E) [✓ 4.]



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

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.

$HCl \xrightarrow{100\%} H^+ + Cl^-$
$\varnothing$ $\uparrow$
0.925 M

$pH = -\log[H^+] = -\log(0.925) = 0.0339$

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.

	$CH_3COOH \rightleftharpoons$	$CH_3COO^- +$	H^+
I	0.925	0	0
C	$-x$	$+x$	$+x$
E	$0.925 - x$	x	x

$K_a = 1.8 \times 10^{-5} = \frac{x^2}{0.925 - \cancel{x}^{\text{out}}}$

$x = [H^+] = 0.00408$
$pH = -\log[H^+] = -\log(0.00408)$
$= 2.39$

37. Because of my OSU chemistry experience...

(A) every night I dream of molecules.
(B) my manners have improved.
(C) my manners have deteriorated.
(D) I am motivated to do really great things.
(E) I am very concerned. My room is decked out with hundreds of molecular models made from taffy, fruit rolls, silly putty, commandeered cafeteria dinner rolls, pipe cleaners, cheese-wiz, and pudding cups.

[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.