Chemistry 122
Final Exam

Winter 2009
March 16, 2009

Oregon State University
Dr. Richard Nafshun

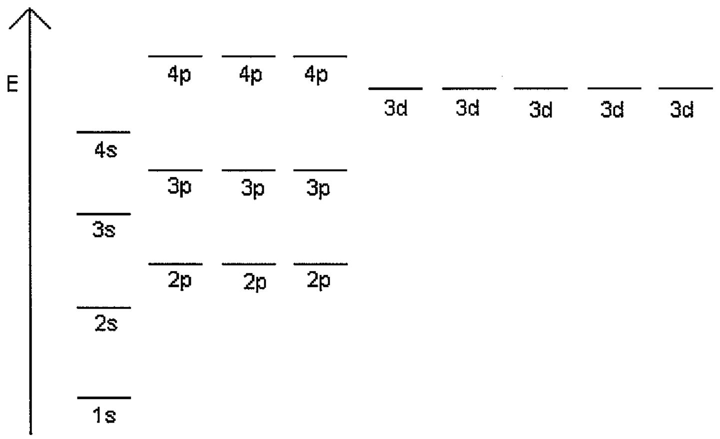
Instructions: You should have with you several number two pencils, an eraser, your 3" x 5" note card, a calculator, and your University ID Card. If you have notes with you, place them in a sealed backpack and place the backpack OUT OF SIGHT or place the notes directly on the table at the front of the 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 33 multiple-choice questions. Each question has four points associated with it (Question 33 has two). 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}
SC: 2r = s	BCC: 4r = s√3	FCC: 4r = s√2

IA																	**VIIIA**
1 H Hydrogen 1.0079	**IIA**											**IIIA**	**IVA**	**VA**	**VIA**	**VIIA**	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	**IIIB**	**IVB**	**VB**	**VIB**	**VIIB**	**VII**			**IB**	**IIB**	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				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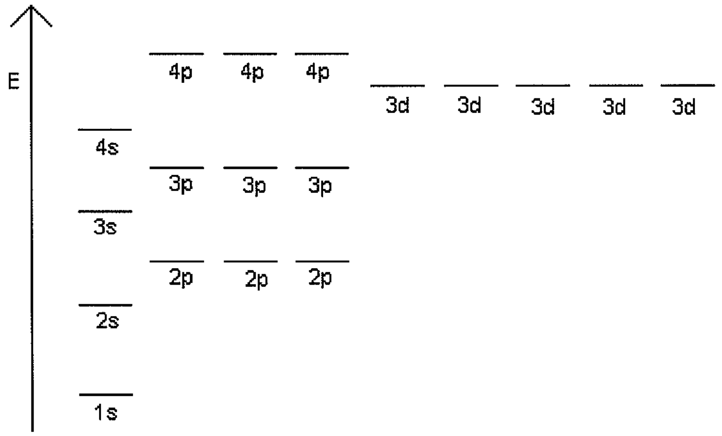
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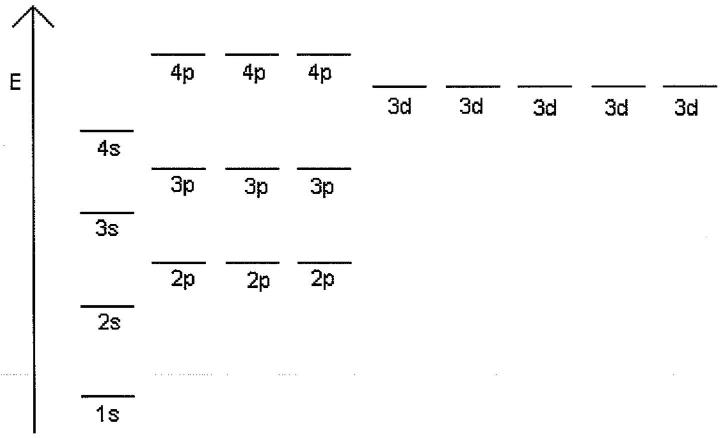
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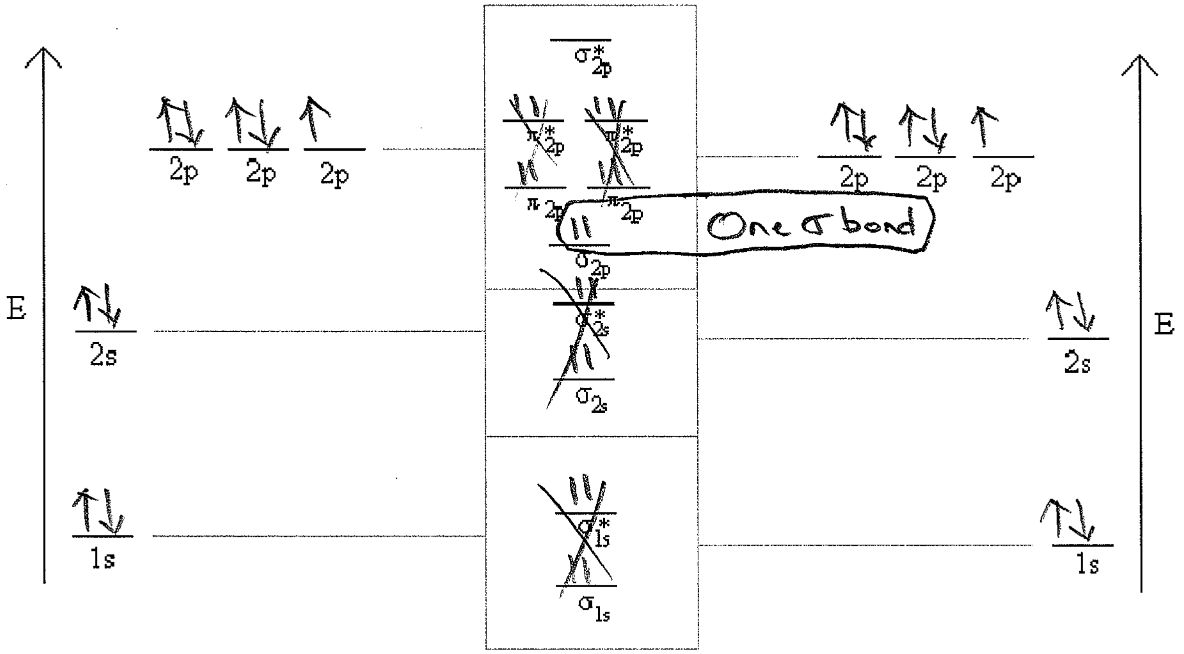
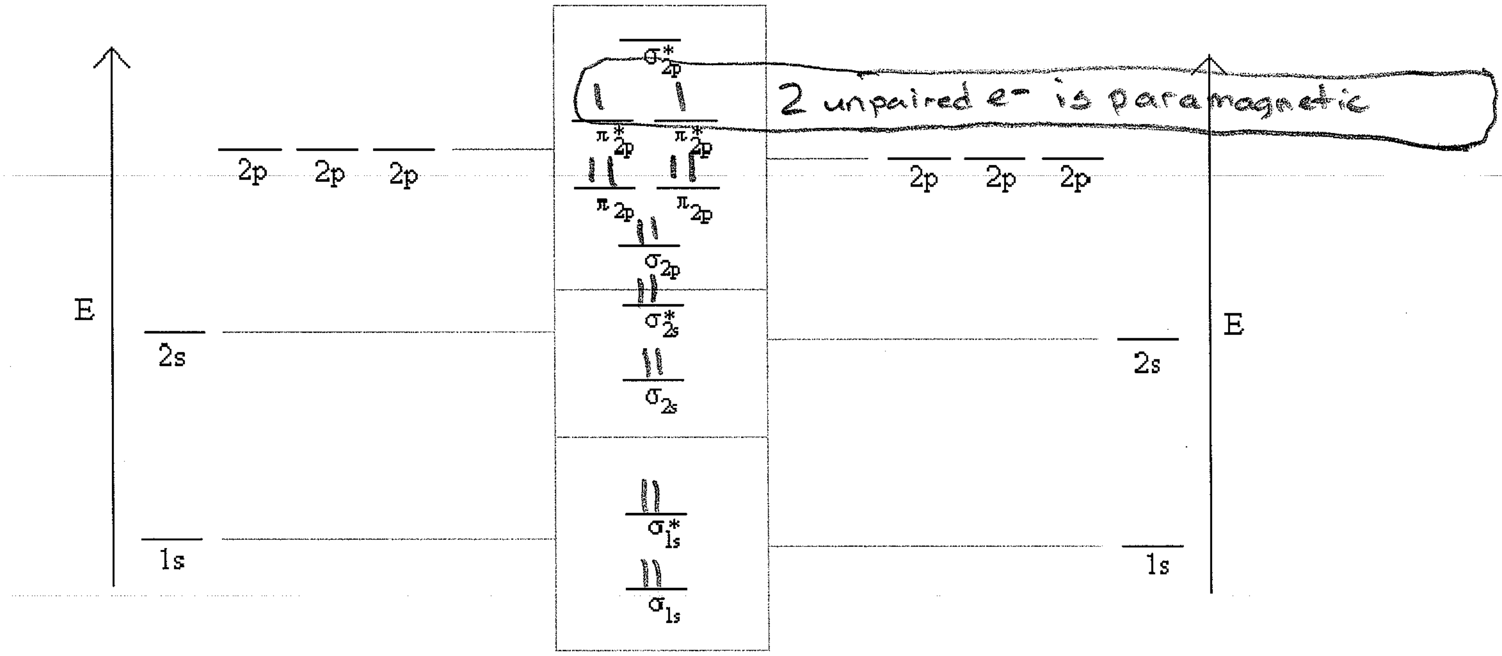
$O_2^{2-} \rightarrow 16+2= 18\ e^-$ system

Question 11



$N_2^{2-} \rightarrow 14+2=16\ e^-$ system

Question 12

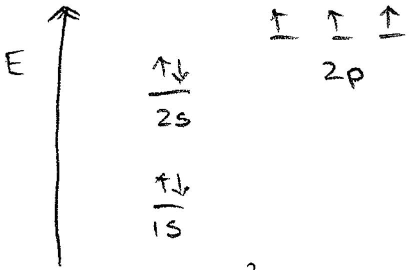


Please read each exam question carefully. Terms such as *correct, false, unpaired, pairs, H-C-F bond angle, H-C-H angle, greatest, and smallest are* used.

Unit 1 Material (First assessed on Exam 1)

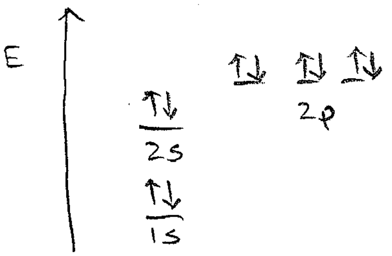
1. There are ___ **unplaired** electrons in a ground-state nitrogen atom. $7e^-$

(A) 0
(B) 1
(C) 2
(D) [✓ 3]
(E) 4



2. The ground-state electron configuration of an oxide ion (O^{2-}) is: $\rightarrow 8+2=10e^-$

(A) $1s^2 2s^2 3s^2 3p^2$
(B) $1s^2 2s^2 3s^1$
(C) $1s^2 2s^2 2p^4$
(D) $1s^2 2s^2 2p^6 3s^2 3p^2$
(E) [✓ $1s^2 2s^2 2p^6$]



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

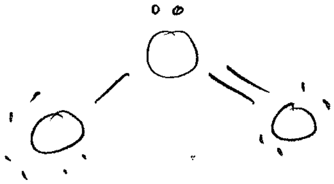
Less e^- than Na
(A) Na^+ is larger than Na
(B) [✓ N^{3-} is larger than N]
More e^- than N

4. The Lewis Dot Structure of CO_2 depicts:

(A) [✓ There are no lone **pairs** of electrons on Carbon]
(B) There is one lone **pair** of electrons on Carbon
(C) There are two lone **pairs** of electrons on Carbon
(D) There are four lone **pairs** of electrons on Carbon
(E) There are six lone **pairs** of electrons on Carbon

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

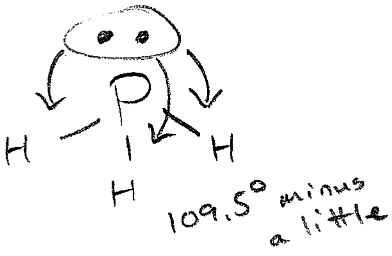
(A) 1.00
(B) 1.33
(C) [✓ 1.50]
(D) 1.75
(E) 2.00



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

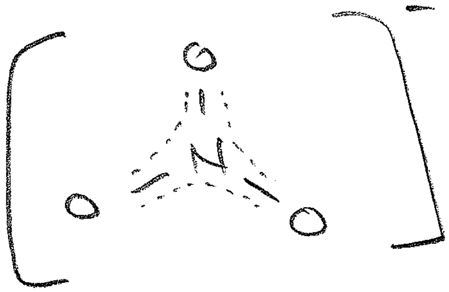
6. The H-P-H bond angle in PH_3 is:

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

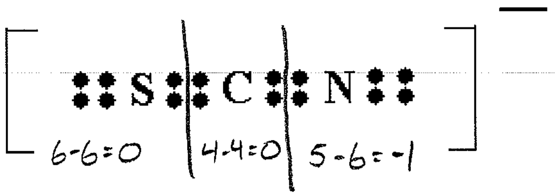


7. The nitrogen-oxygen-nitrogen bond angle in nitrate, NO_3^- is:

(A) 45°
(B) 60°
(C) 90°
(D) [✓ 120°]
(E) 109.5°

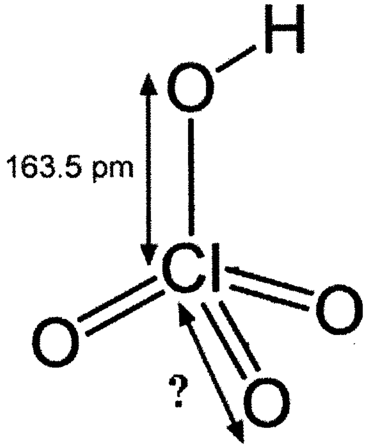


8. A student () proposes the Lewis Dot Structure below for the thiocyanate ion. Determine the formal charge on sulfur in this structure.



(A) The sulfur has a formal charge of -2
(B) The sulfur has a formal charge of -1
(C) [✓ The sulfur has a formal charge of 0]
(D) The sulfur has a formal charge of +1
(E) The sulfur has a formal charge of +2

9. Consider perchloric acid ($HClO_4$; shown below). The length of the chlorine/oxygen bond shown on the bottom side of the picture (with a question mark and diagonal arrow) is:

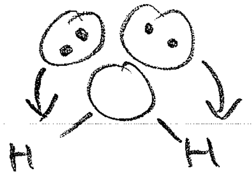


(A) 163.5 pm
(B) Greater than 163.5 pm
(C) [✓ Less than 163.5 pm]

double bonds (σ plus π) are shorter and stronger than single bonds (σ)

10. The deviation from the ideal bond angle in water can be attributed to:

(A) π-Bonding
(B) Polymerization
(C) Hydrogen bonding
(D) [✓ Lone pairs of electrons on oxygen]
(E) Hydrophobia



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

(A) 0.0
(B) 0.5
(C) [✓ 1.0]
(D) 1.5
(E) 2.0

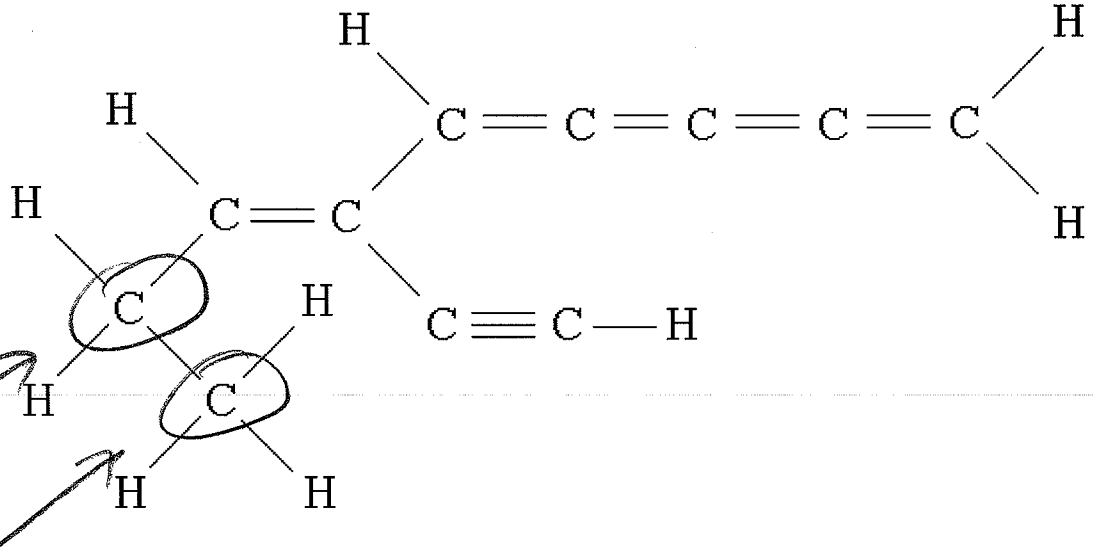
See Page 3 - MO Diagram on top

12. Molecular orbital theory predicts the N_2^{2-} ion (a minus **two** charge) is:

(A) [✓ paramagnetic]
(B) diamagnetic
(C) trimagnetic
(D) totally-magnetic
(E) the-hills-magnetic

See page 3 - MO diagram on bottom

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



TWO sp^3 carbons

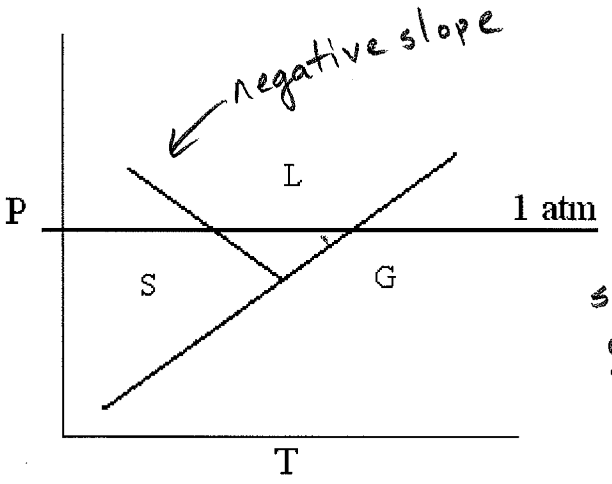
→ T_d C $-\overset{|}{\underset{|}{C}}-$

(A) [✓ There are 2 carbons that have sp^3 hybridization schemes]
(B) There are 3 carbons that have sp^3 hybridization schemes
(C) There are 4 carbons that have sp^3 hybridization schemes
(D) There are 5 carbons that have sp^3 hybridization schemes
(E) There are 6 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



— goes through solid, liquid, and gas

⊕ ⊖
NaF

⊕ ⊖
NaCl

15. Sodium fluoride melts near 993 °C. Sodium chloride melts near 804 °C. The difference in melting points can be attributed to:

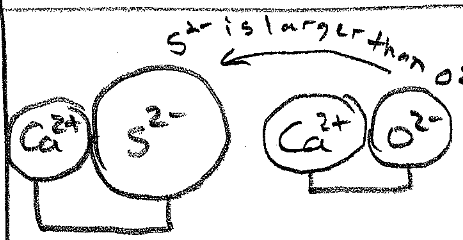
(A) Different intermolecular forces (dispersion, dipole-dipole, hydrogen bonding)
(B) ~~Different ionic charges (+1, +2, +3, -1, -2, -3...)~~
(C) [✓ Different distances between nuclei (ionic size)]
(D) The sheet-like structure
(E) Network covalent compounds

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

(A) Carbon dioxide is a non-polar molecule which exhibits dispersion forces. True
(B) [✓ Cesium oxide is a non-polar molecule which exhibits dipole-dipole forces.] Cs_2O is ionic
(C) Water is a polar molecule which exhibits hydrogen bonding. True
(D) Quartz is a network covalent compound. True
(E) Network covalent compounds typically melt at higher temperatures than molecules. True

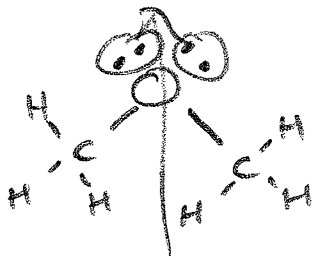
17. Consider CH_3CH_2OH, CaO, CH_3CH_3, CH_3OCH_3, CaS, and Ar. Arranged in increasing melting point, these are:

	Lowest melting point	**Highest melting point**
(A)	$CH_3CH_2OH < Ar < CH_3CH_3 < CH_3OCH_3 < CaO < CaS$	
(B)	$Ar < CH_3CH_3 < CH_3OCH_3 < CH_3CH_2OH < CaO < CaS$	
(C)	$Ar < CH_3OCH_3 < CH_3CH_3 < CH_3CH_2OH < CaS < CaO$	
[✓ (D)]	[✓ $Ar < CH_3CH_3 < CH_3OCH_3 < CH_3CH_2OH < CaS < CaO$]	
(E)	$Ar < CH_3CH_3 < CH_3CH_2OH < CH_3OCH_3 < CaO < CaS$	

Inerts	Molecules	Ionics	Network Covalent compounds
Ar	CH_3CH_3 ① CH_3–O–CH_3 ① ② CH_3CH_2O–H ① ② ③	S^{2-} is larger than O^{2-} 	(None)

18. Draw the Lewis Dot Structure for 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



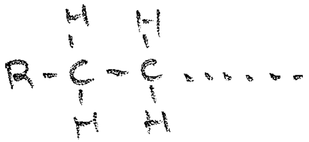
polar molecule

Ⅰ
Ⅱ

No III -
H is not bonded directly to O, N, S, or F

19. The reaction below will produce:

$R^{\bullet} + CH_2CH_2 \rightarrow$


$$R-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}\cdots\cdots$$

(A) Quartz
(B) A network covalent compound
(C) An ionic compound
(D) Soap
[✓ (E) A polymer]

20. The cubic form for the fictitious element GuitarHeroium (Gh) is FCC. The atomic radius is 192.0 pm and the molar mass is 306.7 g/mol. The density of Gh is:
[1 m = 1 x 10^{12} pm 1 m = 100 cm]

(A) g/cm^3
(B) g/cm^3
(C) g/cm^3
(D) g/cm^3
[✓ (E) 12,7 g/cm^3]

$d = \frac{g}{cm^3}$

① g (mass)

$$306.7 \frac{g}{mol}\left(\frac{1 \text{ mol}}{6{,}022\times10^{23} \text{ atoms}}\right)\left(\frac{4 \text{ atoms}}{1 \text{ FCC cell}}\right) = 2.037\times10^{-21} \frac{g}{FCC}$$

② cm^3 (volume)

$$r = 192.0 \text{ pm}\left(\frac{1 \text{ m}}{1\times10^{12} \text{ pm}}\right)\left(\frac{100 \text{ cm}}{1 \text{ m}}\right) = 1{,}92\times10^{-8} \text{ cm}$$

$$4r = s\sqrt{2} \quad \text{OR} \quad s = \frac{4r}{\sqrt{2}} = \frac{(4)(1.92\times10^{-8} \text{ cm})}{\sqrt{2}} = 5.43\times10^{-8} \text{ cm}$$

$$V = s^3 = (5.43\times10^{-8} \text{ cm})^3 = 1.60\times10^{-22} \text{ cm}^3$$

$$d = \frac{m}{Vol} = \frac{2.037\times10^{-21} \text{ g}}{1.60\times10^{-22} \text{ cm}^3} = 12.7$$

21. A student  dissolves 13.50 g of an unknown polymer in 900 mL of water at 304 K. She measures the osmotic pressure to be 0.0441 mm Hg. What is the molar mass of the polymer?

[✓ (A) 6.45 x 10^6 g/mol]
(B) x 10^6 g/mol
(C) x 10^5 g/mol
(D) x 10^6 g/mol
(E) x 10^6 g/mol

$\pi V = nRT$

$$n = \frac{\pi V}{RT} = \frac{\left[\dfrac{0{,}0441 \cancel{\text{mmHg}}}{\dfrac{760 \cancel{\text{mm Hg}}}{1 \cancel{\text{atm}}}}\right](0.900 \cancel{L})}{(0.0821 \frac{\cancel{L}\cdot\cancel{atm}}{mol\cdot\cancel{K}})(304 \cancel{K})} = 2.09\times10^{-6} \text{ mol}$$

$$\text{Molar Mass} = \frac{g}{mol} = \frac{13.50 g}{2.09\times10^{-6} \text{ mol}} = 6{,}451{,}831 \text{ g/mol}$$

or

$$6{,}45\times10^{6} \text{ g/mol}$$

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 20.0 grams of ^{14}C remain?

(A) 5730 years
(B) 1,150 years
(C) 11,500 years
(D) [✓ 13,300 years]
(E) 28,650 years

① Calc k $\ln\frac{1}{2} = -kt_{1/2}$ $-0.6931 = -(k)(5730 y)$

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

② Calc t $\ln\left[\frac{A}{A_o}\right] = -kt$

$\ln\left[\frac{20 g}{100 g}\right] = -(1.2097 \times 10^{-4} \frac{1}{y})(t)$

t = 13,305 y

23. The following are initial rate data for: **A + B → C**

Experiment	Initial [A]	Initial [B]	Initial Rate
1	0.10	0.10	4.5
2	0.20	0.10	18.0
3	0.10	0.20	9.0

Initial [A], 1 → 2: ×2
Initial [B], 1 → 3: ×2
Initial Rate, 1 → 2: ×4 ← $[A]^2$
Initial Rate, 1 → 3: ×2 $[B]^1$

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

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

$\rightarrow$ K^+ Cl^- $i=2$

24. The boiling point of 1.83 m aqueous KCl (aq) is:

(A) 101.05 °C
(B) 101.02 °C
(C) 102.05 °C
[✓ (D) 101.87 °C]
(E) 102.09 °C

$\Delta T_b = i\,m\,k_b = (2)(1.83\ m)(0.512\ \frac{°C}{m}) = 1.87\ °C$

$T_b = 100°C + 1.87°C = 101.87°\ C$

Unit 3 Material (Not previously assessed)

25. The equilibrium law expression for the reaction 2 NO (g) + O_2(g) ⇔ 2 NO_2(g) is:

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

$K = \frac{\text{Products}}{\text{Reactants}} = \frac{[NO_2]^2}{[NO]^2[O_2]}$

26. A solution was made 2.3×10^{-3} M in $[Pb^{2+}]$ and 1.3×10^{-3} M in $[F^-]$. $[K_{sp}\ (PbF_2) = 3.7 \times 10^{-8}]$

(A) A solid will form
(B) [✓ A solid will not form]

$PbF_2(s) \rightleftharpoons Pb^{2+}(aq) + 2F^-(aq)$

$Q = K_{sp} = [Pb^{2+}][F^-]^2 = (2.3\times10^{-3})(1.3\times10^{-3})^2 = 3.89\times10^{-9}$

↑ experimental

$Q < K_{sp}$ No solid will form

27. Consider the system $4\ FeCl_3(aq) + 3\ O_2(g) \Leftrightarrow 2\ Fe_2O_3(aq) + 6\ Cl_2(g)$ $K_c = 0.0844$

A student prepares the system and measures:

$[FeCl_3] = 0.0390$ M $[O_2] = 0.0260$ M $[Fe_2O_3] = 0.0127$ M $[Cl_2] = 0.0552$ M

(A) The system is at equilibrium.
(B) [✓ The system is not at equilibrium.]

$$Q = K_c(\text{experimetal}) = \frac{\text{products}}{\text{reactants}} = \frac{[Fe_2O_3]^2[Cl_2]^6}{[FeCl_3]^4[O_2]^3}$$

$$= \frac{(0.0127)^2(0.0552)^6}{(0.0390)^4(0.0260)^3}$$

$$= 0.1122$$

$Q \neq K$ Not at equilibrium

28. The following reaction is at equilibrium:

$\xrightarrow{\text{heat}}$

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

energy makes the reaction proceed to the right

(A) [✓ The concentration of Br_2 (g) increases when the system is heated]
(B) The concentration of Br_2 (g) decreases when the system is heated
(C) The concentration of Br_2 (g) stays the same when the system is heated

29. The following reaction is at equilibrium:

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

(A) The concentration of H_2 (g) increases when Br_2 (g) is added

(B) [✓ The concentration of H_2 (g) decreases when Br_2 (g) is added]

(C) The concentration of H_2 (g) stays the same when Br_2r (g) is added

When Br_2 is added H_2 is consumed to make HBr

30. The pH of 0.200 M HCl (aq) is:

(A) 2.00

(B) 0.200

(C) 0.301

(D) 1.04

(E) [✓ 0.699]

$pH = -\log\{H^+] = -\log(0.200) = 0.699$

↓

HCl is a strong acid

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

∅ 0.200 M

31. The pH of 0.040 M CH_3COOH (aq) [K =1.8×10^{-5}] is:

(A) 3.74

(B) 0.0360

(C) 0.00360

(D) 2.72

(E) [✓ 3.07]

↓

Weak Acid

	CH_3COOH ⇄	CH_3COO^- +	H^+
I	0.040	0	0
C	$-x$	$+x$	$+x$
E	$0.040 - x$	x	x

$$K_a = 1.8 \times 10^{-5} = \frac{products}{reactants} = \frac{\{CH_3COO^-]\{H^+)}{\{CH_3COOH]} = \frac{(x)(x)}{0.040 - \cancel{x}} \nearrow \text{out}$$

$$1.8 \times 10^{-5} = \frac{x^2}{0.040} \qquad x = \{H^+] = 8.485 \times 10^{-4}$$

$$pH = -\log\{H^+] = -\log(8.485 \times 10^{-4}) = 3.07$$

32. 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)	⇔	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)	⇔	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)	⇔	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)	⇔	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)	⇔	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

	$CH_3COOH \rightleftarrows$	CH_3COO^-	+ H^+
I C E	0.175 −x	x	x

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

(A) Party with Alex and his Cousin
[✓ (B) Dance]
(C) Sleep
(D) Toga! Toga! Toga!
(E) Pop Tarts, Sunny-D, PB&J Sandwiches on Wonder Bread, Rice Krispies Treats, Jell-O, Twinkies, a couple of Luther Burgers, and a collection of High School Musical DVDs!

[Any response will receive full credit; even no response.]
Questions 1 through 32 have four points attached (128 total). Any response to Question 33 will receive full credit (2 Points total); even no response. The point total for this exam is 130 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.