

Chem 111**10:10a section****Final Exam Makeup**

This exam is composed of 50 questions. Go initially through the exam and answer the questions you can answer *quickly*. Then go back and try the ones that are more challenging to you and/or that require calculations. Periodic table, solubility rules, and valuable constants are on the last page of the exam. Feel free to tear it off.

As discussed on the course syllabus, honesty and integrity are absolute essentials for this class. In fairness to others, dishonest behavior will be dealt with to the full extent of University regulations.

1. The average molecular speed in a sample of N₂ gas is 408 m/s at 303 K.

The average molecular speed in a sample of CO₂ gas at the same temperature is:

- 1) 304 m s⁻¹ 2) 381 m s⁻¹ 3) 478 m s⁻¹ 4) 326 m s⁻¹ 5) 600 m s⁻¹

(4) Same temperature means same kinetic energy, so (OWL 12-6d)

$$KE = \frac{1}{2} m_{N_2} u_{N_2}^2 = \frac{1}{2} m_{CO_2} u_{CO_2}^2$$

$$u_{CO_2}^2 = \frac{m_{N_2}}{m_{CO_2}} u_{N_2}^2 = \frac{(2 \times 14.01 \text{ g mol}^{-1})}{(12.01 \text{ g mol}^{-1}) + (2 \times 16.00 \text{ g mol}^{-1})} (408 \text{ m s}^{-1})^2$$

$$= 105980 (\text{m s}^{-1})^2 = (326 \text{ m s}^{-1})^2$$

2. A 1.28 mol sample of Ar gas is confined in a 31.5 liter container at 26.5 °C. If 1.28 mol of F₂ gas is added while doubling both the volume and the temperature, the average kinetic energy per molecule will:

- 1) decrease 2) remain the same 3) increase
4) not enough information 5) I don't have a clue

(3) Temperature determines average kinetic energy Chapter 12

3. A sample of Cl₂ gas is confined in a 2.0 liter container at 50 °C. Then 2.5 mol of He is added, holding both the volume and temperature constant. The pressure will increase because:

- 1) As the number of molecule-wall collisions increases, the force per collision increases.
2) With more molecules in the container, the molecules have higher average speeds.
3) With more molecules per unit volume, the molecules hit the walls of the container more often.
4) With higher average speeds, on average the molecules hit the walls of the container with more force.
5) None of the Above

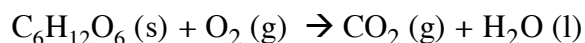
(3) Chapter 12

4. A 1.96 mol sample of CO₂ gas is confined in a 49.1 liter container at 32.3 °C. If the temperature of the gas sample is increased to 55.0 °C, holding the volume constant, the **pressure will increase** because:
- 1) With lower average speeds, the molecules hit the walls of the container less often.
 - 2) As the average speed increases, the number of molecule-wall collisions decreases.
 - 3) With higher average speeds, on average the molecules hit the walls of the container with more force.
 - 4) None of the above

(3)

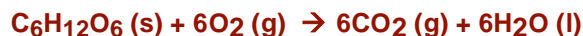
Chapter 12

5. In our bodies, sugar is broken down with oxygen to produce water and carbon dioxide. How many moles of glucose (C₆H₁₂O₆) are required to react completely with 33.6 L of oxygen gas (O₂) according to the following reaction at 0 °C and 1 atm pressure? Note that the reaction may need balancing.



- 1) 6.0 mol 2) 0.250 mol 3) 0.319 mol 4) 0.637 mol 5) 7.13 mol

(2) First, balance the reaction:



6 mol of oxygen reacts with 1 mol of glucose, so first find the the number of moles of

$$\text{O}_2 \text{ gas: } n = \frac{PV}{RT} = \frac{(1 \text{ atm})(33.6 \text{ L})}{(0.0820 \text{ atm L mol}^{-1} \text{ K}^{-1})(273 \text{ K})} = 1.50 \text{ mol}$$

$$\text{Therefore, we need } \left(\frac{1}{6}\right) 1.50 \text{ mol} = 0.250 \text{ mol}$$

OWL 12-3b

6. What is the total volume of gaseous products formed when 160 L of bromine trifluoride (BrF₃) react completely to form Br₂ and F₂? (All gases are at the same temperature and pressure, before and after.)
- 1) 85 L 2) 190 L 3) 380 L 4) 320 L 5) 160 L

(4) First, write a balanced equation:



Look at mole ratios. 4 moles of gases are derived from 2 moles of reactants.

Therefore, the volume should double.

OWL 12-3b

7. The temperature of the atmosphere on Mars can be as high as 27 °C at the equator at noon, and the atmospheric pressure is about 8.0 mm of Hg. If a spacecraft could collect 2.80 m³ of this atmosphere, compress it to a small volume, and send it back to earth, about how many moles would the sample contain?

- 1) 4.3 mol 2) 97 mol 3) 54 mol 4) 0.13 mol 5) 1.2 mol

$$n = \frac{PV}{RT} = \frac{(8.0\text{mm})(2.8\text{m}^3)}{(0.0820\text{ atm L K}^{-1}\text{ mol}^{-1})(27 + 273)\text{K}} \left(\frac{\text{atm}}{760\text{mm}}\right) \left(\frac{100\text{cm}}{\text{m}}\right)^3 \left(\frac{\text{L}}{1000\text{cm}^3}\right)$$

$$n = 1.20\text{ mol}$$

(5)

Chapter 12

8. HNO₃ is (a table on page 1 provides a clue):

- 1) a strong base 2) a weak base 3) a weak acid
4) a strong acid 5) none of the above

(4)

Chapter 5

9. The concentration of H⁺ in table wine (pH 3.4) is:

- 1) 3.98x10⁻⁴ M 2) 3.40x10⁻⁹ M 3) 3.98x10⁴ M
4) 3.40x10⁹ M 5) 1.00x10⁻⁷ M

(1)

Chapter 5 Problem 72

10. Reactions in water that produce gases tend to be:

- 1) unfavorable 2) ugly 3) favorable
4) endothermic 5) exothermic

(3)

Chapter 5

11. Mixing Na₂S with NH₄Cl in water leads to precipitation of:

- 1) a S²⁻ salt 2) a Na⁺ salt 3) a Cl⁻ salt
4) everything precipitates 5) no precipitation

(5)

inspired by OWL 5-2d

12. You need to make an aqueous solution of 0.131 M ammonium sulfide for an experiment in lab, using a 250 mL volumetric flask. How much solid ammonium sulfide should you add?

- 1) 2.23 g 2) 3.15 g 3) 1.24 g 4) 2.74 g 5) 9.11 g

$$(NH_4)_2S \quad \text{Molar Mass} = 2(14.01 + 4(1.008)) + 32.07 = 68.15\text{ g mol}^{-1}$$

$$x \left(\frac{\text{mol}}{68.15\text{g}} \right) \left(\frac{1}{250\text{mL}} \right) \left(\frac{1000\text{mL}}{\text{L}} \right) = 0.131 \frac{\text{mol}}{\text{L}}$$

$$x = 2.23\text{g}$$

(1)

OWL 5-9c

13. Which of the following describes the compound $\text{Ba}(\text{NO}_3)_2$?

- 1) The compound is ionic.
- 2) If the compound dissolved in water it would not conduct electricity.
- 3) If the compound dissolved in water it would be a non-electrolyte.
- 4) The compound is molecular.
- 5) Both (1) and (2)

(1)

(OWL question, Chapter 3)

14. Which reaction below is a redox reaction?

- 1) $\text{NaOH}(\text{aq}) + \text{HNO}_3(\text{aq}) \rightarrow \text{NaNO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- 2) $\text{Na}_2\text{CO}_3(\text{aq}) + 2\text{HClO}_4(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) + 2\text{NaClO}_4$
- 3) $\text{CdCl}_2(\text{aq}) + \text{Na}_2\text{S}(\text{aq}) \rightarrow \text{CdS}(\text{s}) + 2\text{NaCl}(\text{aq})$
- 4) $\text{Zn}(\text{OH})_2(\text{s}) + \text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{ZnSO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- 5) None of the above

(5) Look at redox changes – there are none.

Chapt 5 inspired by book

15. The net ionic equation for the reaction of zinc sulfate and sodium hydroxide is:

- 1) $\text{Zn}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Zn}(\text{OH})_2(\text{s}) + \text{Na}_2\text{SO}_4(\text{aq})$
- 2) $\text{ZnSO}_4(\text{aq}) + 2\text{NaOH}(\text{aq}) \rightarrow \text{Zn}(\text{OH})_2(\text{aq}) + \text{Na}_2\text{SO}_4(\text{aq})$
- 3) $\text{Zn}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Zn}(\text{OH})_2(\text{s})$
- 4) $\text{Zn}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Zn}(\text{OH})_2(\text{aq})$
- 5) No *net* reaction occurs

(3) hydroxide salts are generally insoluble

(OWL 5-2c)

16. In an endothermic process:

- 1) work is performed on the surroundings
- 2) heat is transferred to the surroundings
- 3) work is performed on the system
- 4) heat is transferred to the system

(4)

Chapter 6

17. Change in internal energy is best described as:

- 1) ΔH
- 2) $q+w$
- 3) w
- 4) q
- 5) ΔG

(2) ΔE is change in internal energy. $\Delta E=q+w$

Chapter 6

18. A negative value of ΔE means that:

1. heat is transferred to the surroundings
2. heat is transferred to the system
3. energy in the form of heat and/or work is transferred to the surroundings
4. energy in the form of heat and/or work is transferred to the system

(3)

Chapter 6

19. An automobile engine generates **2160** Joules of heat that must be carried away by the cooling system. The internal energy changes by **-2758** Joules in this process.

How much work to push the pistons is available in this process ?

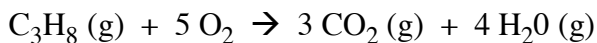
- 1) 598 J 2) 4918 J 3) 2758 J 4) 2160 J 5) 4320 J

$$\Delta E = q + w \quad w = \Delta E - q = (-2758 \text{ J}) - (-2160 \text{ J}) = -598 \text{ J}$$

(1) **w is negative. The system does work on the surroundings.**

Chapter 6

20. Given the standard molar enthalpies of formation shown at right, determine ΔH for the reaction:



- 1) $+530.6 \text{ kJ mol}^{-1}$
- 2) $-530.6 \text{ kJ mol}^{-1}$
- 3) $+2043 \text{ kJ mol}^{-1}$
- 4) $-2043 \text{ kJ mol}^{-1}$
- 5) not enough information to determine

Subst	ΔH_f° (kJ/mol)
$\text{C}_3\text{H}_8 (\text{g})$	-104.70
$\text{CO}_2 (\text{g})$	-393.51
$\text{H}_2\text{O} (\text{g})$	-241.83
$\text{H}_2\text{O} (\text{l})$	-285.83

$$(4) [3(-393.51) + 4(-241.83)] - [(-104.70) + 5(0)] = -2043 \text{ kJ mol}^{-1}$$

Chapt 6

21. Given the information above, what is the heat required to vaporize water at 298 K?

- 1) $-40.65 \text{ kJ mol}^{-1}$
- 2) $44.00 \text{ kJ mol}^{-1}$
- 3) $40.65 \text{ kJ mol}^{-1}$
- 4) $-44.00 \text{ kJ mol}^{-1}$
- 5) not enough information to determine

$$(2) (-241.83) - (-285.83) = 44.00 \text{ kJ mol}^{-1}$$

Chapt 6

22. A 45.5 g sample of copper at 99.8 °C is dropped into a beaker containing 125 g of water at 18.5 °C. When thermal equilibrium is reached, what is the final temperature of the copper? The specific heat capacities of water and copper are 4.184 and 0.385 J g⁻¹ K⁻¹, respectively.

- 1) 21.1 °C 2) 12.5 °C 3) 37.0 °C 4) 90.1 °C 5) 20.7 °C

$$q_{\text{metal}} + q_{\text{water}} = 0$$

$$(0.385 \text{ J g}^{-1} \text{ K}^{-1})(45.5 \text{ g})(x - 99.8) \text{ K} + (4.184 \text{ J g}^{-1} \text{ K}^{-1})(125 \text{ g})(x - 18.5) \text{ K} = 0$$

$$(x - 99.8) \text{ K} = \frac{-(4.184 \text{ J g}^{-1} \text{ K}^{-1})(125 \text{ g})}{(0.385 \text{ J g}^{-1} \text{ K}^{-1})(45.5 \text{ g})}(x - 18.5) \text{ K} = -29.86(x - 18.5) \text{ K}$$

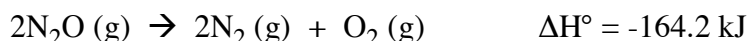
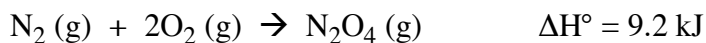
$$x - 99.8 = -29.86x - (18.5)(-29.86)$$

$$x + 29.86x = 99.8 + 552.3 = 771.4$$

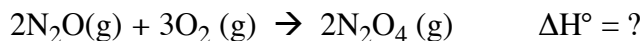
$$x = 21.1$$

(1) Chapt 6 Problem 20 at end of chapter. See also example 6.2

23. Given the following information:



what is the standard enthalpy change for the reaction:



- 1) 155 kJ mol⁻¹ 2) 146 kJ mol⁻¹ 3) -155 kJ mol⁻¹
4) -146 kJ mol⁻¹ 5) not enough information to determine



(4) $\Delta H^\circ = (18.4 - 164.2) \text{ kJ mol}^{-1} = -145.8 \text{ kJ mol}^{-1}$ OWL 6-6c

24. Which of the following has the strongest bond?

- 1) HF 2) HCl 3) HBr 4) HI

(1) – shortest bond, strongest bond OWL 9-xx

25. Being careful to consider molecular orbital theory (or at least valence bond theory), which of the following has the shortest bond length?

- 1) B₂ 2) C₂ 3) N₂ 4) O₂ 5) F₂

(3) N₂ – triple bond OWL 9-xx

26. The central CO bond in the molecule $\text{CH}_3\text{-CO-CH}_3$ is best described as a:

- 1) triple bond
2) double bond
3) single bond
4) ionic bond
5) the molecule doesn't exist

(2) From OWL units 9-1d and 9-2b. See Study Questions 13-14, Chapter 9

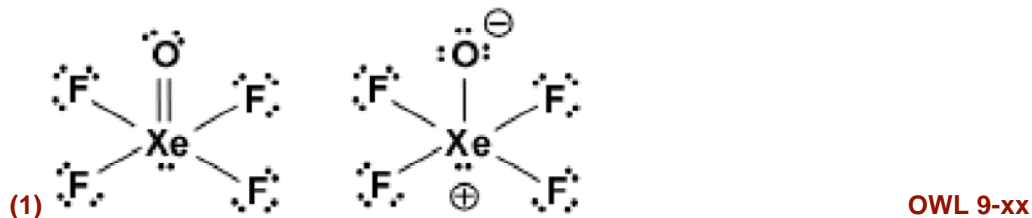
27. Draw the Lewis structure for CO^{2-} . What is the bond order of the CO bond?

- 1) triple
2) double
3) single

(2) double $[\text{:}\ddot{\text{C}}=\ddot{\text{O}}\text{:}]^{2-}$ **(12 valence electrons)** **OWL 9-xx**

28. Draw the Lewis structure for XeOF_4 (Xe is the central atom). What is the hybridization on Xe?

- 1) sp^3d^2
2) sp^3d^3
3) sp^3d
4) sp^3
5) sp^2



29. The molecule XeOF_4 is:

- 1) nonpolar
2) polar
3) can't tell

(2) polar – the individual dipoles do not cancel out. **OWL 9-10b**

30. A molecule has sp^3d hybridization with one lone pair. The **electron pair geometry** of this molecule is:

- 1) tetrahedral
2) octahedral
3) linear
4) square pyramidal
5) trigonal bipyramidal

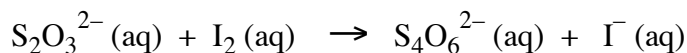
(5) from OWL 10-2b

31. Using molecular orbital theory, what is the bond order in the anion F_2^- ?

- 1) 0.5
2) 1.0
3) 1.5
4) 2
5) 0

(1) OWL 10-xx

32. Consider the unbalanced equation:

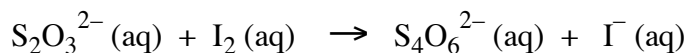


In the balanced equation, the coefficient in front of $\text{I}^-(\text{aq})$ is:

- 1) 1 2) 2 3) 3 4) 4 5) 6



33. Considering that same reaction



A reducing agent in this reaction is:

- 1) $\text{S}_2\text{O}_3^{2-}$ 2) I_2 3) neither



34. Which radiation below has the longest wavelength?

- 1) blue light (6.8×10^{14} Hz) 4) microwaves (2.4×10^9 Hz)
 2) green light (6.0×10^{14} Hz) 5) x-rays (5.0×10^{18} Hz)
 3) red light (4.5×10^{14} Hz)



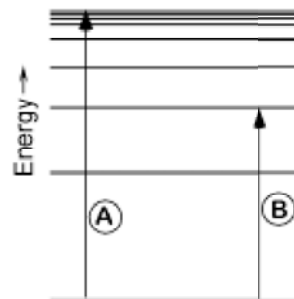
35. What is the wavelength of visible light with frequency 1.00×10^{15} Hz?

- 1) 600 nm 2) 300 nm 3) 500 nm 4) 162 nm 5) 280 nm

(2) $\lambda = \left(\frac{2.9998 \times 10^8 \text{ m}}{\text{s}} \right) \left(\frac{1}{1.00 \times 10^{15} \text{ Hz}} \right) \left(\frac{\text{Hz} \cdot \text{s}}{1 \cdot 1} \right) = 3.00 \times 10^{-7} \text{ m}$ (OWL)
 $= 3.00 \times 10^{-7} \text{ m} \left(\frac{10^9 \text{ nm}}{\text{m}} \right) = 300 \text{ nm}$

36. Consider the diagram at right. The transition labeled B is *best* described as :

- 1) emission 2) absorption
 3) ionization 4) electron capture



37. The principle quantum number n specifies:

- 1) orbital orientation
- 2) subshell orbital shape
- 3) transition probability
- 4) orbital karma
- 5) energy and distance from nucleus

(5)

From OWL Unit 7-7b

38. The correct spectroscopic notation for the sulfur ion S^{-} is:

- 1) $1s^2 2s^2 2p^6 3s^2 3p^2$
- 2) $1s^2 2s^2 2p^6 3s^2 3p^3$
- 3) $1s^2 2s^2 2p^6 3s^2 3p^4$
- 4) $1s^2 2s^2 2p^6 3s^2 3p^5$
- 5) $1s^2 2s^2 2p^6 3s^2 3p^6$

(4)

From OWL Unit 8-7c

39. Which of the following elements has the greatest difference between the first and second ionization energies?

- 1) Mg
- 2) Si
- 3) P
- 4) Na
- 5) Cl

(4)

See Study Questions 67-68 & 72, Chapter 8 of K&T

40. Which list below is in order of increasing electron affinity?

- 1) $Ne < F < O < N$
- 2) $Si < P < S < Cl$
- 3) $F < Cl < Br < I$
- 4) $Be < Mg < Ca < Sr$
- 5) none of the above

(2)

Chapter 8

41. Which list below is in order of increasing ionization energy?

- 1) $Cl < S < P < Si$
- 2) $Ne < F < O < N$
- 3) $F < Cl < Br < I$
- 4) $Sr < Ca < Mg < Be$
- 5) none of the above

(4)

Chapter 8

42. Which molecule below does not exist?

- 1) CaF_3
- 2) BeF_2
- 3) MgO
- 4) KCl
- 5) $BeCl_2$

(1) See Study Question 33, Chapter 9 of K&T – think about ionization required to make ionic compounds (Chapt 9.3)

43. The molecule HF can be thought of as having both ionic and covalent character. Given that statement, which of the following is likely to best describe the charge on each atom?

	H	F
1)	+1.0	-1.0
2)	+0.7	-0.7
3)	0.0	0.0
4)	-0.7	+0.7
5)	-1.0	+1.0

(2) This question is intended to get you thinking about concepts we will need in the next chapter. The key here is BOTH ionic and covalent. Answers (4) and (5) should be immediately eliminated – F wants to be negative, H positive. If the molecule were purely covalent (as in FF), (3) would be correct – but the molecule is not purely covalent. If the molecule were purely ionic (as in NaCl), (1) would be correct – but the molecule is not purely ionic. This leaves (2) as the only reasonable answer.

44. What is the most common charge of ions formed from **Fr**?

1) +1 2) +2 3) -1 4) -2 5) -3

(1) +1

(OWL question, Chapter 3)

45. What is the formula of the compound formed between the ions **Co³⁺** and **O²⁻** ?

1) CoO 2) Co₂O 3) Co₂O₃ 4) Co₃O₂ 5) CoO₂

(3) Co₂O₃ -> 2 Co³⁺ + 3 O²⁻

(OWL question, Chapter 3)

46. What is the molar mass of **nitrogen trioxide**?

1) 62 g/mol 2) 32 g/mol 3) 44 g/mol 4) 16 g/mol 5) 46 g/mol

(1) NO₃ $1\left(14.0067 \frac{\text{g}}{\text{mol}}\right) + 3\left(16.00 \frac{\text{g}}{\text{mol}}\right) = 62.0 \frac{\text{g}}{\text{mol}}$ **(OWL, Chapt 3)**

47. A sample of citric acid, **C₆H₈O₇**, contains 0.153 mol of the compound. What is the mass of this sample, in grams?

1) 3.02 g 2) 13.7 g 3) 20.2 g 4) 0.0730 g 5) 29.4 g

First we need the molar mass of citric acid:

$6(\text{molar mass of C}) + 8(\text{molar mass of H}) + 7(\text{molar mass of O}) =$

$6\left(12.011 \frac{\text{g}}{\text{mol}}\right) + 8\left(1.0079 \frac{\text{g}}{\text{mol}}\right) + 7\left(15.9994 \frac{\text{g}}{\text{mol}}\right) = 192.12 \frac{\text{g}}{\text{mol}}$

Use that to calculate the mass:

(5) $(0.153 \text{ mol})\left(\frac{192.12 \text{ g}}{\text{mol}}\right) = 29.4 \text{ g}$

(OWL question, Chapt 3)

48. What is the (mass) percent composition of C in citric acid, $C_6H_8O_7$?

- 1) 6.87% 2) 4.20% 3) 37.5% 4) 28.5% 5) 6.00%

(3) Mass of C in 1 mol of the compound: $(6\text{ mol})(12.01\text{ g/mol}) = 72.06\text{ g}$

Mass of 1 mol of the compound: 192.12 g (see above)

Percent composition: $\frac{72.06\text{ g C}}{192\text{ g}} 100\% = 37.5\%$ **(OWL question, Chapt 3)**

49. Ethylene glycol, $C_2H_6O_2$, is an ingredient in automobile antifreeze. Its density is 1.11 g/cm^3 at 20°C . If you need exactly 1000 mL of ethylene glycol, what mass of the compound, in grams, is required?

- 1) 901 g 2) 90.1 g 3) 111g 4) 1000 g 5) 1110 g

(5) $1000\text{ mL} \left(\frac{1\text{ cm}^3}{1\text{ mL}} \right) \left(\frac{1.11\text{ g}}{\text{cm}^3} \right) = 1110\text{ g}$

(book question, Chapt 2)

50. The correct designator for this course is:

- 1) SOM 555 2) Chem 363 3) Chem 256 4) Sports 1 5) Chem 111

(5)

