

Name _____

Circle one: Abassi Castillo Ciskowska Jarzecki Kahanda Shakya

Write your name on this page and on the next page.

For questions 33–45 you must show work. The exam adds to 100 points.

This exam has 45 questions and 13 pages. Make sure you have all of them. **Work quickly.**
Your time is limited to **2 hours and 15 minutes.**Use of **cell phones** is forbidden and they will be confiscated if used. **Calculators** will be inspected.**Put all work on the exam. Scrap paper is not allowed.**

$$h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s} \quad c = 3.00 \times 10^8 \text{ m/s} \quad R = 0.08206 \text{ L-atm/mol-K}$$

PERIODIC CHART

1A	2A											3A	4A	5A	6A	7A	8A
1 H 1.0079																1 H 1.0079	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179
11 Na 22.989	12 Mg 24.305											13 Al 26.981	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.88	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.69	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.905	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 * La 138.90	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.0	89 # Ac 227.03															

* Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
# Actinides	90 Th 232.03	91 Pa 231.03	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (257)	102 No (255)	103 Lr (256)

Name _____

ALL work and answers go on the question sheets. No scrap paper allowed

1. (6 pts) Draw the Lewis electron dot structure of each of these molecules.

(a) NO_3^- (note the charge) (b) C_2H_2 (c) BrF_3 (d) CO

2. (2 pts) For **each** of these molecules, state whether or not it has a dipole moment:

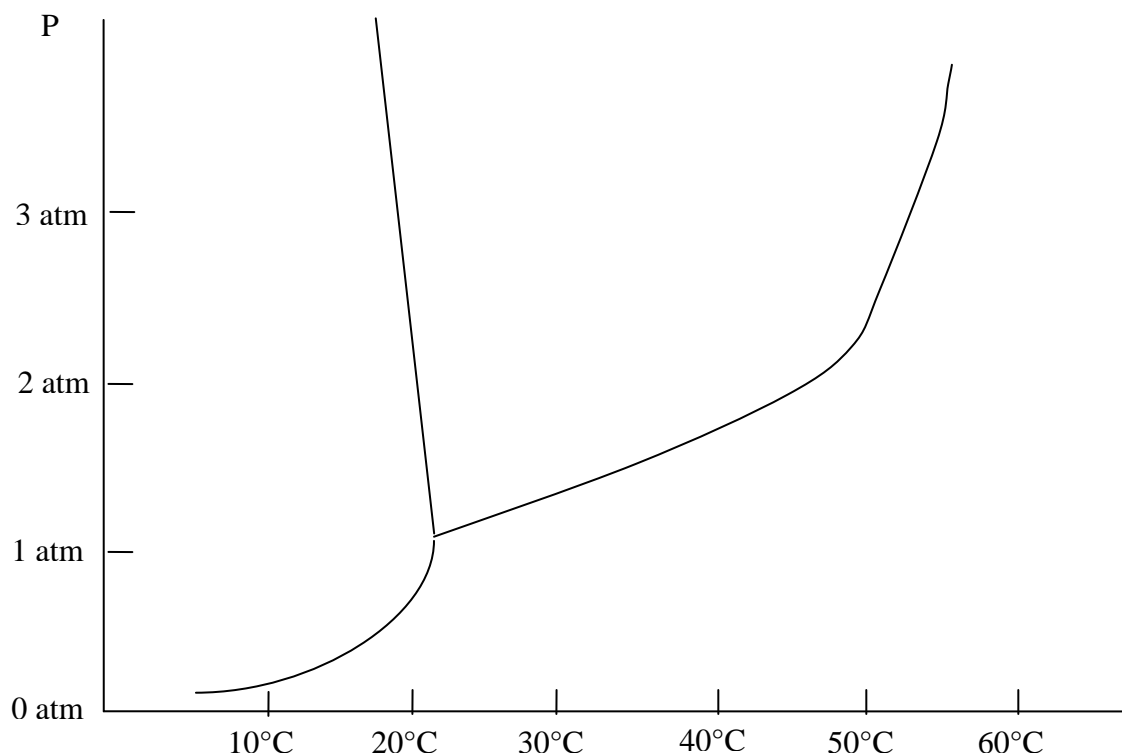
(a) NH_3 (b) CCl_4 (tetrahedral shape)

3. (1 pt.) (a) Which one of these elements has the smallest ionization energy?

Na, Mg, K

4. (1 pt) Draw the Lewis electron dot formula for NaF.

5. (3 pts) This is the phase diagram for substance J:



(a) At 30°C and 2 atm, is J a solid, a liquid, or a gas?

(b) What is the boiling point of liquid J at 2 atm pressure? (You do not need to spend a lot of time to get a highly accurate answer, but your answer should be approximately right.)

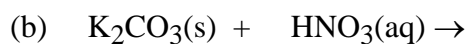
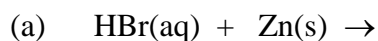
(c) In order for solid J to melt to a liquid when warmed, the pressure must be

_____ atm. (Write the word “above” or “below” on the first blank line and put a number on the second blank line.)

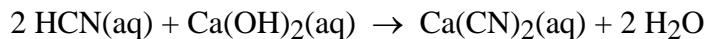
6. (1 pt) Arrange these atoms in order of increasing atomic radius (the smallest atom goes first):

Li, Be, Na

7. (2 pts) Complete and balance these reactions. Do not write net ionic reactions. Zn is above H in the activity series



8. (1 pt) Write the following reaction as a net ionic reaction. Hint: The reaction has a weak electrolyte in it.



9. (5 pts) For each of these molecules with the Lewis structure shown, describe the **molecular** geometry in words. Do NOT give the electron-pair (electron-domain) geometry. Choose your answer from the following:

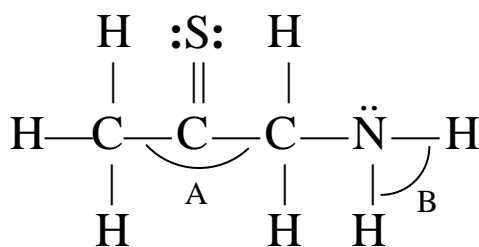
bent, linear, trigonal planar, square planar, trigonal pyramidal, tetrahedral, octahedral, square pyramidal, trigonal bipyramidal, T-shaped, seesaw, shapeless.

- (a) AY_4 , with A as the central atom, with a single bond to each Y atom, and with two lone pairs on A.
- (b) WZ_2 , with W as the central atom, with a single bond to each Z atom, and with three lone pairs on W.
- (c) XY_2 , with X as the central atom, with a single bond to each Y, and with two lone pairs on X.
- (d) XY_5 , with X as the central atom, with a single bond to each Y, and with no lone pairs on X.
- (e) MB_2 , with M as the central atom, with a double bond to each B atom, and with no lone pairs on M.

10. (4 pts) For each of the molecules (a) to (d) in question 9, give the bond angle or bond angles. If the angle is a little less than a certain value, you must state this.

- (a) (b) (c) (d)

11. (2 pts) In the molecule



- (a) give the value of the bond angle A.

(b) give the value of the bond angle B.

12. (1 pt) The boiling point of H_2Se is higher than the boiling point of H_2S . This is because (see the periodic table to help you)

- (a) The bonds in H_2Se are more polar than the bonds in H_2S
- (b) The bonds in H_2Se are less polar than the bonds in H_2S .
- (c) The London dispersion forces in H_2Se are larger than those in H_2S .
- (d) The London dispersion forces in H_2Se are smaller than those in H_2S .

13. (1 pt) The boiling point of H_2O is higher than the boiling point of H_2S . Give the name of the kind of intermolecular force that is responsible for this higher boiling point.

14. (1 pt) Name this compound



15. (4 pts) Give the formula of each of these compounds

- (a) iron(III) sulfate
- (b) magnesium nitrite
- (c) nitric acid
- (d) mercury(I) chlorate (this one is tricky)

16. (1 pt) Give **all** the possible values of the m_l quantum number for a 5d electron.

17. (2 pts) Classify the **bond(s)** in each of these molecules as ionic, nonpolar covalent, or polar covalent. (No credit for covalent as the answer.)

- (a) CO_2
- (b) F_2

18. (2 pts) Give the complete electron configuration of the Fe^{3+} ion. Do **not** use the inert-gas abbreviation

19 (3 pts) (a) How many electrons are there in one H_3O^+ ion? Count ALL the electrons, not just the valence electrons.

(b) How many protons are there in one H_3O^+ ion?

(c) How many nuclei are there in one H_3O^+ ion?

20. (3 pts) True or false?

(a) As pure water freezes, the temperature of the mixture of water and ice stays constant until all the water has frozen.

(b) Two uncharged molecules cannot exert any forces on each other.

(c) The solubility of a salt such as NaCl in liquid C_6H_{14} would likely be very small.

21. (1 pt) 849 m^2 is equal to

(a) 8.49 cm^2 (b) 0.0849 cm^2 (c) 84900 cm^2 (d) $849 \times 10^4 \text{ cm}^2$ (e) $849 \times 10^6 \text{ cm}^2$

22. (1 pt) A student weighs 0.040 g of KCl. To the correct number of significant figures, how many moles of KCl did the student take? **Hint:** There is no need to do a calculation to answer this.

(a) 0.0005 (b) 0.00054 (c) 0.000537 (d) 0.0005372 (e) none of these answers

23. (1 pt) This diagram shows the lowest three energy levels of the H atom (note the different spacings between levels). The energy increases as we go up in the diagram.

— $n = 3$

— $n = 2$

— $n = 1$

In which one of the following changes in energy level is the **lowest**-frequency photon emitted or absorbed?

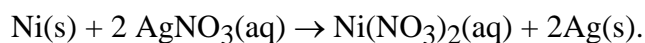
(a) $n = 1$ to $n = 2$ (b) $n = 1$ to $n = 3$ (c) $n = 2$ to $n = 3$

24. (1 pt) For the change $n = 1$ to $n = 3$ in question 23, is a photon absorbed or is a photon emitted?

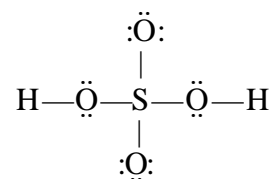
25. (1 pt) Find the molarity of the Na^+ ion in 0.40 M $\text{Na}_2\text{SO}_4(\text{aq})$.

26. (1 pt) Give the formula of the compound formed by Ga (group 3A) and S (group 6a).

27. (1 pt) Which substance is being oxidized in this reaction? If you think nothing is being oxidized, say "nothing is being oxidized."



28. (1 pt.) Find the formal charge on the S atom in this Lewis structure:



29. (3 pts) A student dissolves 85.0 g of NaCl in 425 g of H_2O to give a solution whose volume is 454 cm^3 . The volume of 425 g of water is 425 cm^3 .

(a) Find the NaCl molality (not molarity) in the solution.

(b) Find the NaCl mole fraction in this solution.

30. (1 pt.) Consider the elements C, N, Si

(a) Which one of these three is the most nonmetallic?

(b) Which one of these three is the least nonmetallic

31. (1½ pts) Which **one** of the following sets of quantum numbers is **allowed** as the quantum numbers of an electron in an atom?
- (a) $n = 4, l = 4, m_l = -1, m_s = \frac{1}{2}$
 - (b) $n = 2, l = -1, m_l = -1, m_s = \frac{1}{2}$
 - (c) $n = 0, l = 0, m_l = 0, m_s = \frac{1}{2}$
 - (d) $n = 4, l = 2, m_l = 0, m_s = -\frac{1}{2}$
 - (e) $n = 4, l = 3, m_l = 1, m_s = -1$
 - (f) $n = 2, l = 1, m_l = 2, m_s = \frac{1}{2}$

32. (1½ pts) A certain compound has the empirical formula CH_2O and its molecular weight is 210 amu. What is the molecular formula of this compound.

Part II

For questions 33 to 45, put all work on the question sheet next to the multiple choice answers. To get credit on one of these questions, you **MUST SHOW WORK ON THE QUESTION SHEET AND YOU MUST CHOOSE THE CORRECT MULTIPLE-CHOICE ANSWER**. A correct answer with no work or with irrelevant work gets no credit. Your work does NOT have to be neat. See Page 1 for values of constants.

33. (3 pts) What mass of $\text{O}_2(\text{g})$ is needed to react with 68.4 g of C_2H_4 to produce CO_2 and H_2O ?
You **MUST show work here and you must choose the correct multiple-choice answer.**
- (a) 60.4 g
 - (b) 78.4 g
 - (c) 166 g
 - (d) 234 g
 - (e) 300 g

34. (3 pts) Find the empirical formula of a compound if a sample of this compound contains 21.82 g of phosphorous and 28.18 g of oxygen. (Phosphorous is below N in the periodic table.) **Show work here.**

- (a) PO_2
- (b) PO
- (c) P_2O_3
- (d) P_3O_2
- (e) P_2O_5
- (f) P_5O_2

35. (3 pts) How many atoms of F are present in 56.5 g of NF_3 ? **Show work here.**

- (a) 1.62×10^{23}
- (b) 1.44×10^{24}
- (c) 4.79×10^{23}
- (d) 1.22×10^{-21}
- (e) 1.06×10^{22}

36. (3 pts) A student wants to prepare 250 mL of a 0.850 M $\text{NaCl}(\text{aq})$ solution by adding water to a 14.5 M $\text{NaCl}(\text{aq})$ solution. What volume of the 14.5 M solution should the student take? **Show work here.**

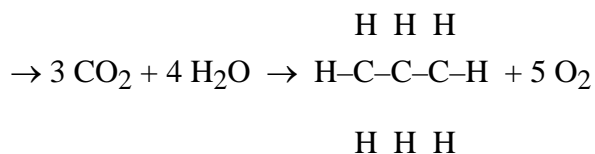
- (a) 14.7 mL
- (b) 20.3 mL
- (c) 24.9 mL
- (d) 20.3 L
- (e) 8.30 mL

37. (3 pts) Given these bond energies in kJ/mol

$$D(\text{H-H}) = 436, \quad D(\text{H-C}) = 413, \quad D(\text{C-C}) = 348, \quad D(\text{C=C}) = 614,$$

$$D(\text{O}_2) = 495, \quad D(\text{C-O}) = 396, \quad D(\text{C=O}) = 799, \quad D(\text{O-H}) = 463$$

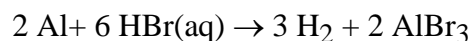
Find ΔH for the following gas-phase reaction:



Show work here.

- (a) -2023 kJ/mol
- (b) 2023 kJ/mol
- (c) -2542 kJ/mol
- (d) 2542 kJ/mol
- (e) -2754 kJ/mol
- (f) 2754 kJ/mol

38. (3 pts) For the reaction



what volume of 0.300 M HBr(aq) is needed to react with 22.6 g of Al? (Al is in Group 3A.)

Show work here. (Reminder: to get credit, you must choose the right answer **and** you must show work on the question sheets.)

- (a) 3.96 L
- (b) 8.38 L
- (c) 2.80 L
- (d) 12.9 L
- (e) 6.70 L

39. (3 pts) A 6.250 g sample of a compound of C, H, and O when burned in oxygen produces 11.958 g of CO_2 and 7.336 g of H_2O . Find the mass of **oxygen** in the 6.250 g sample. Do NOT find the empirical formula. You must **show work here**.

- (a) 4.348 g
- (b) 1.959 g
- (c) 3.641 g
- (d) 2.166 g
- (e) 3.235 g

40. (3 pts) For the reaction $3\text{H}_2 + \text{N}_2 \rightarrow 2\text{NH}_3$, suppose 20 g of H_2 and 84 g of N_2 are present at the start of the reaction. At the end of the reaction, which one of the following will be left over (unreacted). **Show work here.**

- (a) 2.0 g of H_2
- (b) 3.2 g of H_2
- (c) 4.0 g of H_2
- (d) 4.0 g of N_2
- (e) 5.4 g of N_2
- (f) 7.7 g of N_2

41. (3 pts) Violet light has a wavelength of 400 nm, where $1 \text{ nm} = 10^{-9} \text{ m}$. Find the energy of one photon of violet light. **Show work here.**

- (a) $2.65 \times 10^{-40} \text{ J}$
- (b) $7.96 \times 10^{-32} \text{ J}$
- (c) $3.44 \times 10^{-22} \text{ J}$
- (d) $6.31 \times 10^{-20} \text{ J}$
- (e) $4.97 \times 10^{-19} \text{ J}$

42. (3 pts) Find the molecular weight of a gas if 2.00 g of this gas in a 500 cm^3 container at 27°C exerts a pressure of 545 torr. (One atm = 760 torr.) **You must show work here.**

- (a) 46 amu
- (b) 308 amu
- (c) 137 amu
- (d) 512 amu
- (e) 204 amu

43. (3 pts) The heat of vaporization of liquid water is 40.59 kJ/mol . The specific heat of liquid water is $4.18 \text{ J/g}\cdot^\circ\text{C}$. The specific heat of water vapor is $2.01 \text{ J/g}\cdot^\circ\text{C}$. How much heat is needed to convert 234 g of liquid water at 30°C and 1 atm to water vapor at 140°C and 1 atm? Be careful with units. **Show work here.**

- (a) 889 kJ
- (b) 502 kJ
- (c) 372 kJ
- (d) 444 kJ
- (e) 615 kJ

44. (3 pts) The freezing point of pure C_6H_6 is 5.50°C . A solution of 3.44 g of the nonelectrolyte compound X in 122 g of C_6H_6 freezes at 4.10°C . Find the molecular weight of compound X. The freezing-point-depression constant of C_6H_6 is $5.12^\circ\text{C}/(\text{mol/kg})$. **Show work here.**

- (a) 93 amu
- (b) 103 amu
- (c) 119 amu
- (d) 138 amu
- (e) 221 amu

45. (3 pts) The density of a 3.92 M solution of NaCl in water is 1.148 g/cm^3 at 20°C . Find the molality of this solution. The formula weight of NaCl is 58.44 amu. *Hint*: Take a convenient amount of solution. **Show work here.**

- (a) 3.08 mol/kg
- (b) 3.47 mol/kg
- (c) 3.76 mol/kg
- (d) 3.92 mol/kg
- (e) 4.27 mol/kg

Extra credit

EC1 (1 pt) Classify each of the following solids as ionic, covalent network, molecular, or metallic.

- (a) H_2O (b) diamond

EC2 (1 pt.) Find the vapor pressure of a 12 weight % solution of the nonvolatile nonelectrolyte $\text{C}_6\text{H}_{12}\text{O}_6$ in water at 25°C . The vapor pressure of water at 25°C is 23.756 torr.

EC3. (½ pt) Chamber A contains pure water. Chamber B contains a solution of sucrose in water. These chambers are separated by a membrane that is permeable to water but impermeable to sucrose. Which statement is true, where π is the osmotic pressure?

- (a) Water flows from Chamber A to B until the pressure in B exceeds the pressure in A by π .
- (b) Water flows from Chamber A to B until the pressure in A exceeds the pressure in B by π .
- (c) Water flows from Chamber B to A until the pressure in B exceeds the pressure in A by π .
- (d) Water flows from Chamber B to A until the pressure in A exceeds the pressure in B by π .

