

This exam consists of six pages. Make sure you have one of each. Print your name at the top of each page now. Pages 7 and 8 contain some thermochemical data, important constants, a table of electronegativities, and a periodic table. You may tear both off and use them for scratch paper. Show your work on calculations, including unit conversions, and give answers in the correct units and appropriate number of significant figures. In problems involving molecular and formula weights, you may use values rounded to the nearest 0.1 amu.

Page Points

1 _____
2 _____
3 _____
4 _____
5 _____
6 _____

If anything confuses you or is not clear, raise your hand and ask!

Total _____

Points

(6) 1. Complete and balance the following chemical equations. In cases where the name of the substance is given, give the formula under the name. In cases where a ? is given, fill in the missing compound under the ?.

(a) potassium hydroxide + bromous acid \rightarrow potassium bromite + ?

(b) $C_{12}H_{22}O_{11} + O_2 \rightarrow ? + ?$

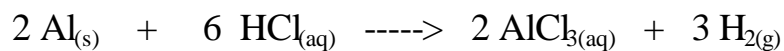
(4) 2. Give the atomic symbol, including Z, A, and q in the proper location, for atoms or ions containing the following number of particles:

(a) 15 protons, 16 neutrons,
18 electrons

(b) 47 protons, 61 neutrons,
46 electrons

(5) 3. How many L of a 0.12 M solution of $Ba(OH)_2$ is required to neutralize 0.31 L of a solution of 0.47 M HCl? Write the equation for the reaction. Show your work.

4. Given the following balanced chemical equation:



(3) (a) How many grams of Al will be required to produce 25.4 g of hydrogen gas?

(b) 2.5 Moles of Al are added to a solution containing 6.5 moles of HCl.

(2) (1) Which reagent is limiting?

(2) (2) How many moles of the excess reagent will remain after the reaction?

(2) (3) How many moles of H₂ will be produced in the reaction?

(5) 5. A compound containing C, H, and O yields the following analysis:
54.6% Carbon, 9.1% Hydrogen, 36.4% Oxygen. Determine the empirical formula.

6. Calculate the ΔH for the following reaction in three different ways, using the thermochemical data given at the end of the test:



- (4) (a) Using bond energy data.
- (4) (b) Using heats of formation data.
- (4) (c) Using heats of combustion data. (Hint: Write the equations for complete combustion of both reactants and products, and use Hess's Law to combine the ΔH for those steps to give the ΔH for the above reaction).
- (4) 7. How many joules of heat energy will be required to raise the temperature of 25 grams of ice from -24°C to liquid water at 85°C ?

(4) 8. What is the energy of a mole of photons having a wavelength of 450 nm?

(4) 9. What is the frequency of a photon of light emitted by a hydrogen atom in which the electron drops from the fourth Bohr orbit to the first Bohr orbit?

(3) 10. Write the abbreviated electron configuration (using the rare gas core, i.e. C = {He}2s²2p²) for the following:

Ni

Si

Ga

(4) 11. Give the value of the quantum number l associated with electrons in each of the following orbitals:

	2p	5f	3s	4d
$l =$	_____	_____	_____	_____

(3) 12. Comparing the elements Br and Cl, which

(a) Has the higher ionization energy? _____

(b) Has the larger atomic radius? _____

(c) Is most reactive with metals? _____

(3) 13. Comparing the elements Na and P, which

(a) Has the higher ionization energy? _____

(b) Has the larger atomic radius? _____

(c) Forms an oxide which reacts with water to produce a basic solution? _____

- (12) 14. For each of the following compounds or ions, draw the best Lewis dot structure. (If more than one resonance structure is "best", draw only one). The central atom is underlined. Give the electron pair geometry, the molecular geometry, and the hybridization about the central atom.

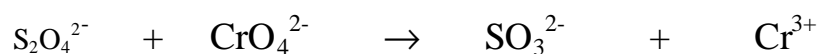
<u>Compound</u>	<u>Lewis Structure</u>	<u>Electron pair Geometry</u>	<u>Molecular Geometry</u>	<u>Hybridization</u>
<u>C</u> H ₂ O				
<u>Xe</u> F ₄				
<u>Cl</u> O ₃ ⁻				

- (3) 15. Draw three Lewis Dot resonance structures for SO_3^{2-} in which the central sulfur atom has a zero formal charge. Label the formal charges on each oxygen. Must the octet rule be violated to draw these structures?

- (5) 16. What volume of oxygen, measured at 273 K and 1.00 atm pressure, must be used to completely burn 32.0 grams of C_3H_8 ? (Write the balanced equation for the reaction).

- (5) 17. A 0.400 L lecture bottle of gas contains a mixture of 78.0 mole % nitrogen, 13.0 mole % oxygen, and 9.0 mole % CO_2 at 25 °C and 12.4 atm pressure. How many moles of each gas are present in the cylinder?

- (9) 18. Given the following oxidation-reduction reaction:



- (a) Identify: The reagent being oxidized _____
 The reagent being reduced _____
 The oxidizing agent _____
 The reducing agent _____

- (b) Balance the equation **in basic solution**.

The following tables of data may be useful to you.

Physical constants:

$$c = 3.00 \times 10^8 \text{ ms}^{-1}$$

$$h = 6.63 \times 10^{-34} \text{ J-s}$$

$$R_H = 2.18 \times 10^{-18} \text{ J}$$

$$R = 0.0821 \text{ L-atm/mol-K}$$

$$\Delta H \text{ of fusion of ice} = 6.008 \text{ kJ/mol;}$$

$$\Delta H \text{ of vaporization of water} = 40.67 \text{ kJ/mol;}$$

$$\text{Specific heat of ice} = 2.092 \text{ J/g-K}$$

$$\text{Specific heat of water} = 4.184 \text{ J/g-K;}$$

Heats of Formation:

Substance	ΔH_f° kJ/mol	Substance	ΔH_f° kJ/mol
CO(g)	-110.5	CaO(s)	-635.1
CO ₂ (g)	-393.5	CaCO ₃ (s)	-1207.1
CH ₃ OH(l)	-238.6	Ca(OH) ₂ (s)	-986.1
C ₂ H ₅ OH(l)	-277.7	Mg(g)	147.1
H ₂ O(l)	-285.8	Mg ²⁺ (g)	2335.1
H ₂ O(g)	-241.8	Mg ⁺ (g)	885.1
C ₂ H ₆ (g)	-84.7	MgO(s)	-601.7
C ₂ H ₄ (g)	52.3	Li(g)	159.3
C ₂ H ₂ (g)	226.7	Cl(g)	121.7
C ₆ H ₆ (l)	49.0	F(g)	80.0
C ₄ H ₁₀ (g)	-124.7	LiCl(s)	-408.3
CH ₂ O(g)	-117.0	Li ⁺ (g)	685.7
CH ₃ COOH(l)	-484.1	Cl(g)	-227
C ₆ H ₁₂ O ₆ (s)	-1273.3	F(g)	-252

Heats of Combustion

Substance	$\Delta H_{\text{combustion}}$ kJ/mol	Substance	$\Delta H_{\text{combustion}}$ kJ/mol
C (s)	-393.5	CO (g)	-283.0
CH ₄ (g)	-890	H ₂ (g)	-285.9
C ₃ H ₈ (g)	-2220	C ₆ H ₆ (l)	-3267
CH ₃ OH (l)	-726.5	C ₂ H ₅ OH (l)	-1366.7
C ₂ H ₄ (g)	-1410.9	C ₂ H ₂ (g)	-1299.6
C ₂ H ₆ (g)	-1559.7	C ₆ H ₁₂ O ₆ (s)	-2816

Average Bond Energies (kJ/mol)

Single Bonds:

C-H	413	N-H	391	O-H	463	F-F	155
C-C	348	N-N	163	O-O	146		
C-N	293	N-O	201	O-F	190	Cl-F	253
C-O	358	N-F	272	O-Cl	203	Cl-Cl	242
C-F	485	N-Cl	200	O-I	234		
C-Cl	328	N-Br	243			Br-F	237
C-Br	276			S-H	339	Br-Cl	218
C-I	240	H-H	436	S-F	327	Br-Br	193
C-S	259	H-F	567	S-Cl	253		
		H-Cl	431	S-Br	218	I-Cl	208
Si-H	323	H-Br	366	S-S	266	I-Br	175
Si-Si	226	H-I	299			I-I	151
Si-C	301						
Si-O	368						

Multiple Bonds:

C=C	614	N=N	418	O ₂	495
C≡C	839	N≡N	941		
C=N	615			S=O	523
C≡N	891			S=S	418
C=O	799				
C≡O	1072				

Some Electronegativities

H 2.1	(2A)	(3A)	(4A)	(5A)	(6A)	(7A)
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8
[Transition Metals 1.0-2.4]						
Rb 0.8					Te 2.1	I 2.5
Cs 0.7					Po 2.0	At 2.2

1A 1 H 1.008	2A 4 Be 9.01																			8A 2 He 4.003														
3 Li 6.94	5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18																												
11 Na 22.99	12 Mg 24.31	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.06	17 Cl 35.45	18 Ar 39.95	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80									
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	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* 138.91	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 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
87 Fr (223)	88 Ra 226.03	89 Ac** 227.03	104 Rf (263)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (269)	109 Mt (268)	110 Uun (272)	111 Uuu	112 Uub	113	114 Uuq	115	116 Uuh	117	118 Uuo																	

*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 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
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** Actinides

90 Th 232.04	91 Pa 231.04	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 (258)	102 No (259)	103 Lr (262)
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