

You May Remove this page from the front of the exam

Avogadro's number: $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

Periodic Table of the Elements

1 1A	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA												
1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8	9 9	10 10	11 11	12 12	13 13A	14 14A	15 15A	16 16A	17 17A	18 18A												
1 H Hydrogen 1.008	2 He Helium 4.003	3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180	11 Na Sodium 22.990	12 Mg Magnesium 24.305	13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948												
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798												
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294												
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71 Lanthanide Series	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018												
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103 Actinide Series	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [268]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]												
57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

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JBA 2017 – Chemistry Exam 1

Name: _____ Score: _____/100 = _____/80

1. Which of the following is a member of the group of elements called the *halogens*? (2 points)

- a. potassium
- b. calcium
- c. bromine
- d. argon

Answer c

2. When beryllium forms an ion, what charge will the ion have? (2 points)

- a. +1
- b. -1
- c. +2
- d. -2

Answer c

3. The electron configuration for manganese is: (2 points)

- a. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$
- b. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$
- c. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^7$
- d. $1s^2 2s^2 2p^6 3s^2$

Answer b

4. Which item below IS NOT part of Dalton's atomic theory? (2 points)

- a. All atoms of a particular element are identical
- b. Atoms combine in whole number ratios to form compounds.
- c. Atoms can be split into protons, neutrons and electrons
- d. Reactions involve the rearrangement of atoms.

Answer c

5. Below are four statements about protons, only one of which is true. Identify the true statement. (2 points)

- a. Protons have about the same mass as electrons.
- b. Protons have about the same mass as neutrons.
- c. Some atoms don't have any protons.
- d. Protons have the same magnitude of charge as neutrons, but opposite sign

Answer b

6. Which of these bonds do you expect to be the most polar? (2 points)

- a. F-F
- b. O-F
- c. N-F
- d. C-F

Answer d

7. Which of the following elements occurs naturally as a diatomic molecule? (2 points)

- a. sulfur
- b. helium
- c. carbon
- d. oxygen

Answer d

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8. Match the term with its definition. (8 points)

<u>B</u> electron	A. a dumb bell shape in space where an electron or a pair of electrons can be found
<u>I</u> mass number	B. a subatomic particle with a mass of 1/1824 and a charge of -1
<u>F</u> amphiphilic	C. negatively charged species that forms when an atom gains one or more electrons
<u>E</u> compound	D. a generalization that in most stable molecules, all atoms except hydrogen will share in eight outer electrons
<u>H</u> covalent bond	E. a pure substance made up of two or more elements in a fixed characteristic chemical combination and composition
<u>D</u> octet rule	F. a property of compounds that lets them dissolve in polar solvents (like water) as well as nonpolar solvents.
<u>C</u> anion	G. atoms of the same element, but with different number of neutrons
<u>G</u> isotopes	H. a chemical bond created when two atoms share electrons.
	I. the number of protons and neutrons that atom contains.
	J. positively charged species that forms when an atom loses one or more electrons

9. Complete the following table. (6 points)

<u>147</u> g H ₂ O	=	8.14 mol H ₂ O	=	4.90 x 10²⁴ molecules H ₂ O
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In order to relate moles and mass, we need to use the molar mass, so we must calculate the molar mass of water:

$$\frac{2 \text{ mol H}}{1 \text{ mol H}_2\text{O}} \times \frac{1.01 \text{ g}}{1 \text{ mol H}} + \frac{1 \text{ mol O}}{1 \text{ mol H}_2\text{O}} \times \frac{16.00 \text{ g}}{1 \text{ mol O}} = \frac{18.02 \text{ g}}{1 \text{ mol H}_2\text{O}}$$

Therefore, the molar mass of H₂O is 18.02 g/mol

Now the conversion between moles and grams:

$$8.14 \text{ mol H}_2\text{O} \times \frac{18.02 \text{ g}}{1 \text{ mol H}_2\text{O}} = 146.68 \text{ g} = \mathbf{147 \text{ g H}_2\text{O}}$$

To convert between moles and molecules, we use Avogadro's number that tells us that 1 mol = 6.022 x 10²³ molecules.

$$8.14 \text{ mol H}_2\text{O} \times \frac{6.022 \times 10^{23} \text{ molecules}}{1 \text{ mol H}_2\text{O}} = 4.9019 \times 10^{24} \text{ molecules} = \mathbf{4.90 \times 10^{24} \text{ molecules H}_2\text{O}}$$

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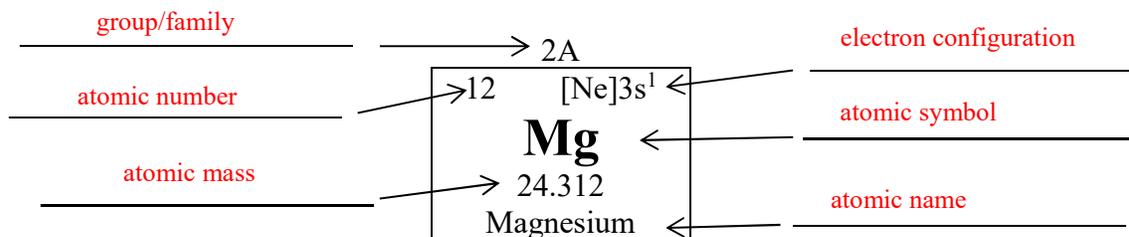
10. Complete the following table. (10 points)

Symbol	$^{12}_6\text{C}$	$^{55}_{26}\text{Fe}$	$^{40}_{20}\text{Ca}^{2+}$
# of protons	6	26	20
# of neutrons	6	29	20
# of electrons	6	26	18
Charge	0	0	+2
Mass #	12	55	40
Atomic #	6	26	20

11. Complete the table below: (8 points)

Formula	Name
ZnS	zinc (II) sulfide
N ₂ O ₅	dinitrogen pentoxide
PF ₆	phosphorous hexafluoride
Na ₂ O	sodium oxide

12. Fill-in the proper term for each item indicated on the diagram below. The terms are group/family, electronic configuration, atomic number, atomic mass, atomic symbol, atomic name. (6 points)



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13. In a butane lighter, 9.7 g of butane react completely with 34.7 grams of oxygen to form carbon dioxide and water. (*Hint: Use the laws of conservation of matter and definite proportions, a balanced reaction is unnecessary*) (8 points, 4 points each part)
- a. If 29.3 grams of carbon dioxide are produced, how many grams of water are formed?

Since the law of conservation of matter must be obeyed, the total mass of butane and oxygen must be equal to the total mass of carbon dioxide and water produced (since the butane and oxygen react completely).

Mass butane + mass oxygen = mass carbon dioxide + mass water

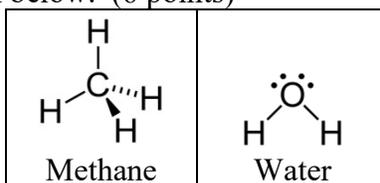
$$9.7\text{g} + 34.7\text{g} = 29.3\text{g} + \text{g water}$$

$$\text{g water} = (9.7 + 34.7) - 29.3 = \mathbf{15.1 \text{ grams water produced}}$$

- b. How many grams of carbon dioxide would be produced if 15.6 grams of butane were allowed to react with 34.7 grams of oxygen?

Here we have increased the mass of butane but left the mass of oxygen alone. Therefore, the oxygen will be our limiting reactant and it will be consumed completely when 9.7g of butane has been reacted. As a result, the mass of carbon dioxide produced would be the same as in part a, **29.3 grams**.

14. Use your understanding of molecular structure and intermolecular forces to explain why methane (CH₄) is a gas at room temperature and water (H₂O) is a liquid. The structures for methane and water are shown below. (6 points)



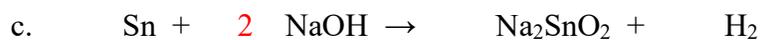
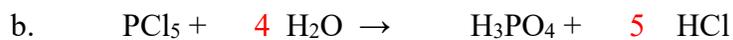
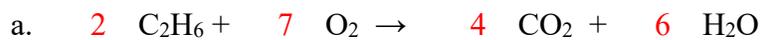
You should talk about the fact that methane is a nonpolar molecule, but water is polar, due to the electronegativity differences of atoms in the bonds and the orientation of the bonds in the molecule. As a result, water can undergo stronger intermolecular forces (like dipole-dipole interactions), that methane cannot. These stronger intermolecular forces require more energy to disrupt, making it more difficult to cause water to go from the liquid phase to the gas phase (that is, to boil).

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15. Draw Lewis structures for the following compounds and determine their shape and polarity.
(12 pts)

Species	Draw the Lewis Structure	<u>Molecular Shape</u> Circle the correct shape. (You may build a model)	Polar Molecule? Circle yes or no.
NH ₃	$\begin{array}{c} \text{H}-\ddot{\text{N}}-\text{H} \\ \\ \text{H} \end{array}$	Linear Bent Trigonal Planar Trigonal Pyramidal Tetrahedral	Yes No
CH ₂ O	$\begin{array}{c} \text{:O:} \\ \\ \text{H}-\text{C}-\text{H} \end{array}$	Linear Bent Trigonal Planar Trigonal Pyramidal Tetrahedral	Yes No
O ₂	$\ddot{\text{O}}=\ddot{\text{O}}$	Linear Bent Trigonal Planar Trigonal Pyramidal Tetrahedral	Yes No

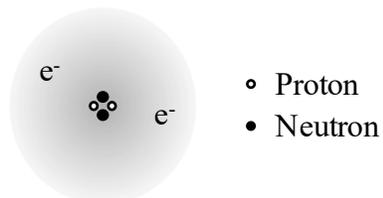
16. Balance the following reactions: (12 points)



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17. Describe what an individual helium atom (${}^4_2\text{He}$) looks like. Be as detailed as you can. You may wish to include a sketch. (5 points)

Helium atoms are comprised of a nucleus that contains two protons and two neutrons and comprises most of the mass of the atom. The remainder of the atom consists of an electron cloud containing two electrons and mostly empty space. A sketch might look something like this:



18. You purchased a bottle of imitation vanilla containing 150 mL of solution. If the solution contains 1.5% V/V of vanillin (the active ingredient), how many mL of vanillin does the bottle contain? (5 Points)

1.5 % V/V means 1.5 mL vanillin per 100 mL of solution, therefore:

$$150 \text{ mL solution} \times \frac{1.5 \text{ g vanillin}}{100 \text{ mL solution}} = 2.25 \text{ mL vanillin} = \mathbf{2.2 \text{ mL vanillin}}$$