

Name: _____

This is a practice test for CH 231 Midterm 2. There are 23 questions in total and it is out of 78 points. It is of similar difficulty of what can be expected on the actual midterm. Please treat it as a real examination, with no outside help from notes, internet, or peers. Take 80 minutes to complete this practice test and remember to keep in mind significant figures. Once done, let James know for the answer key. Good luck!

$\lambda = \frac{h}{mv}$	$q = mc\Delta T$	$q = m\Delta H$
$\Delta E = q + w$	$q = c \Delta T$	$c = 3.00 \times 10^8 \text{ m/s}$
$h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$	$\nu = \frac{c}{\lambda}$	$E = h\nu$
$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$	$R_H = 2.180 \times 10^{-18} \text{ J/photon}$	$R_H = 10973731.6 \text{ m}^{-1}$
$1 \text{ J} = 1 \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$	electron mass = $9.10938 \times 10^{-31} \text{ kg}$	$E = mc^2$
$E\Psi = H\Psi$	$\Delta E = q + w$	$W = -P\Delta V$
$\Delta H = \Delta E - P\Delta V$	$P(r) = 4 \pi r^2 \Psi^2$	$(\Delta x)(m\Delta v) \geq h/4\pi$
$E_n = -hcR_\infty/n^2$	$E_n = -RZ^2/n^2$	$KE = E_{\text{photon}} - \phi$

1 1A	1 H Hydrogen 1.008	2 He Helium 4.003	3 Li Lithium 6.941	4 Be Beryllium 9.012	5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18	11 Na Sodium 22.99	12 Mg Magnesium 24.31	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95	19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80	37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.96	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.7	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29	55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.05	71 Lu Lutetium 174.97	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (208.98)	85 At Astatine (209.99)	86 Rn Radon (222.02)	87 Fr Francium (223.02)	88 Ra Radium (226.03)	89 Ac Actinium (227.03)	90 Th Thorium 232.04	91 Pa Protactinium 231.04	92 U Uranium 238.03	93 Np Neptunium (237.05)	94 Pu Plutonium (244.06)	95 Am Americium (243.06)	96 Cm Curium (247.07)	97 Bk Berkelium (247.07)	98 Cf Californium (251.08)	99 Es Einsteinium (252.08)	100 Fm Fermium (257.10)	101 Md Mendelevium (258.10)	102 No Nobelium (259.10)	103 Lr Lawrencium (262.11)	104 Rf Rutherfordium (261.11)	105 Db Dubnium (262.11)	106 Sg Seaborgium (266.12)	107 Bh Bohrium (264.12)	108 Hs Hassium (269.13)	109 Mt Meitnerium (268.14)	110 Ds Darmstadtium (271)	111 Rg Roentgenium (272)	112 Cn Copernicium (285)	113	114 Fl Flerovium (289)	115	116 Lv Livermorium (293)	117	118
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Multiple Choice Section and Short Answer (16 questions, 3 points each, 48 points total)

1) Which of the following are false regarding covalent bonding?

- a) Polar covalent bonding occurs in compound with a relatively small electronegativity differential
- b) Covalent bonding involves the sharing of electrons
- c) Covalent bonding is a type of directional bonding with electrons located along a bond axis
- d) Covalent bonding can only occur between non-metals
- e) Pi bonds arise from two unhybridized p orbitals
- f) They are all true

2) Rank the following atoms by increasing effective nuclear charge Z_{eff}

Mg, Cl Si Ca

- a) $\text{Cl} < \text{Si} < \text{Mg} < \text{Ca}$
- b) $\text{Mg} = \text{Ca} < \text{Si} < \text{Cl}$
- c) $\text{Si} < \text{Cl} < \text{Mg} = \text{Ca}$
- d) $\text{Mg} = \text{Ca} < \text{Cl} < \text{Si}$
- e) $\text{Mg} < \text{Ca} < \text{Si} < \text{Cl}$

3) With respect to resonance, which of the following statements is false?

- a) Covalent bonding can give rise to resonance structures that “resonate” to a structure that is the average of all those structures found in nature
- b) Triple bonds are more stable than single bonds
- c) Lewis Structures with multiple resonance are more stable than those without it
- d) Resonance requires the presence of pi bonds
- e) CO_3^{2-} will exhibit resonance
- f) They are all true

4) Of the following, ____ is an example of a metal that is isoelectronic to Cu^+

- a) Ni
- b) Ga^+
- c) Ga^{3+}
- d) Zn^+
- e) Zn^{3+}

5) Chemical bonds form because:

- a) Doing so lowers the potential energy between charged particles that compose atoms
- b) Doing so raises the potential energy of atoms comprised of the molecule, which can subsequently be released through breaking of bonds
- c) Doing so allows protons of one atom to combine with electron of another to form the neutrons of a more stable molecule
- d) Bonded molecules occupy smaller volume compared to non-bonded individual atoms
- e) Bonds forming is an exothermic process which requires release of energy between atoms when they interact

6) A Gen Chem student fills out the orbital box diagram for a certain atom below. Which rule(s) are they violating?



- a) Aufbau Principle only
- b) Hund's Rule and Pauli Exclusion Principle
- c) Aufbau Principle and Pauli Exclusion Principle
- d) Aufbau Principle and Hund's Rule
- e) Aufbau Principle, Hund's Rule, and Pauli Exclusion Principle
- f) They are not violating any

7) Of the following structures, which is the most stable?

- a. $\left[:\text{O} \equiv \text{C} - \ddot{\text{N}}: \right]^-$
- b. $\left[:\ddot{\text{O}} - \text{C} \equiv \text{N}: \right]^-$
- c. $\left[:\ddot{\text{O}} = \ddot{\text{C}} - \ddot{\text{N}}: \right]^-$
- d. $\left[:\text{O} \equiv \text{C} = \ddot{\text{N}}: \right]^-$
- e. $\left[:\ddot{\text{O}} - \text{C} = \ddot{\text{N}}: \right]^-$

8) Which of the following characteristics apply to PCl_3 ?

- i. Nonpolar molecule
- ii. Contains polar bonds
- iii. Trigonal-pyramidal molecular geometry
- iv. sp^2 hybridized

- a) i and iii
- b) ii and iii
- c) iii and iv
- d) i, ii and iii
- e) i, ii, iii, and iv

9) Place the following in order of increasing radius:

Br^- Ca Ca^{2+} Rb^+

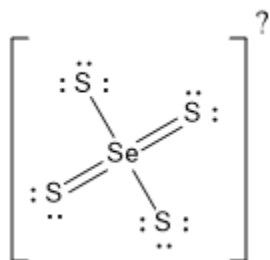
- a) $\text{Br}^- < \text{Rb}^+ < \text{Ca} < \text{Ca}^{2+}$
- b) $\text{Ca} < \text{Ca}^{2+} < \text{Br}^- < \text{Rb}^+$
- c) $\text{Ca} < \text{Ca}^{2+} < \text{Br}^- < \text{Rb}^+$
- d) $\text{Ca}^{2+} < \text{Ca} < \text{Rb}^+ < \text{Br}^-$
- e) $\text{Ca}^{2+} < \text{Ca} < \text{Br}^- < \text{Rb}^+$

10) Which of the following pairs of formulas and names are incorrect?

- i) $\text{Fe}_3(\text{PO}_4)_2$; iron (III) phosphate
- ii) NH_4OH ; ammonium hydroxide
- iii) BaBr_2 ; barium dibromide
- iv) $\text{Al}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$; aluminum nitrate hexahydrate
- v) TiS_2 ; titanium (IV) sulfide

- a) i only
- b) i and iii
- c) ii and iv
- d) iii, iv, and v
- e) i, iv and v
- f) i, iii, and iv
- g) i, iii, iv, and v

For questions 11-14 consider the molecule below:



11) The overall charge of this molecule is:

- a) -2 b) -1 c) 0 d) +1 e) +2

12) The molecule has a hybridization of:

- a) sp^2 b) sp^3 c) sp^3d d) sp^3d^2 e) spd^4

13) The molecule has a bond angle of approximately ____ degrees:

- a) 90 b) 107.5 c) 109.5 d) 117 e) 120

14) The molecule has ____ sigma bonds and ____ pi bonds

- a) 6; 0 b) 2; 4 c) 4; 2 d) 4; 6 e) 6; 4

15) Of the following molecules, only _____ is polar.

- a) CCl_4
b) NCl_3
c) Cl_2
d) BCl_3
e) $BeCl_2$

16) Which of the following statements is false?

- a) The first ionization energy of Cl is greater than S
b) The first ionization energy of Ba is smaller than Be
c) The first ionization energy of Al is smaller than that of Mg
d) The first ionization energy of Se is smaller than that of As
e) The second ionization energy of K is greater than the second ionization energy of Ca
f) They are all true

Quantitative Problem and Written Response (7 questions, 30 points)

17) Calcium acetate is used to control high blood levels of phosphorous in people with kidney disease. (3)

- a) Write out the chemical formula for calcium acetate _____
- b) What is the percent mass of calcium in calcium acetate?

18) How many **ions** can be obtained from the formation of rubidium carbonate when an amorphous sample of rubidium (Rb) that is 2.3cm long, 1.6cm wide and 0.55cm tall is completely reacted into rubidium carbonate? Density of rubidium = 1.532g/cm^3 (3)

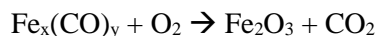
19) Briefly explain each of the following observations using principles of atomic structure and/or bonding (3)

- a) Potassium has a lower first-ionization energy than lithium.
- b) A calcium atom is larger than a zinc atom.
- c) Boron has a lower first-ionization energy than beryllium.

20) A ruthenium plate is struck by a photon with wavelength of 360 nm. The plate has binding energy of 3.88×10^{-20} Joules. (8)

- a) Write the complete electron configuration for ruthenium (shorthand acceptable)
- b) Draw the orbital box diagram for the ruthenium ion that is most likely to form (shorthand acceptable)
- c) What is the total energy of one mole of this photon?
- d) If an electron is ejected from the surface, what would its velocity be?
- e) What is the uncertainty in the position of this electron with a **certainty** of 65% in its velocity?

21) To find the formula of a compound composed of iron and carbon monoxide, $\text{Fe}_x(\text{CO})_y$, the compound is burned in pure oxygen, (O_2). A reaction proceeds according to the following unbalanced equation. (5)



You burn 1.959 g of $\text{Fe}_x(\text{CO})_y$ and obtain 0.799 g of Fe_2O_3 and 2.200 g of CO_2

- a) How much oxygen was used in this reaction?
- b) What is the correct nomenclature for Fe_2O_3 ? _____
- c) What is the empirical formula of $\text{Fe}_x(\text{CO})_y$?

22) Sketch a molecular orbital diagram for OF^- (3)

- a) What is its bond order?
- b) Is it paramagnetic or diamagnetic? Explain why or why not
- c) Is this molecule likely to exist? Explain why or why not

23) Consider a hypothetical polyatomic molecule, VWX , where the elements are all p-block elements beyond the second group of the periodic table and is most stable with a net charge of -1. (5)

Draw the **most stable** Lewis Structure for VWX^{-1} . Include all resonance structures if applicable and in a sentence or two, explain why it is the most stable. For the most stable molecule, state the electron and molecular geometry, hybridization, and denote dipole moments. Elemental analysis found the following:

Element	Electronegativity	Properties
V	2.4	Similar properties to carbon
W	3.5	Exists freely as 2^- anion
X	2.8	In group 5a