last name _____ first name _____ uteid _____ signature _____

1												13	14	15	16	17	18
1 H 1.008	2																2 He 4.003
3 Li 6.941	4 Be 9.012											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	3	4	5	6	7	8	9	10	11	12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	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 72.64	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 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

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
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (266)

constants

$R = 0.08206$ L atm/mol K

$R = 8.314$ J/mol K

$N_A = 6.022 \times 10^{23}$ /mol

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^{8}$ m/s

$F = 96485$ C/mol e$^-$

$e = 1.602 \times 10^{-19}$ C

$m_e = 9.11 \times 10^{-31}$ kg

Rydberg Constants

$\mathcal{R} = 2.18 \times 10^{-18}$ J

$\mathcal{R} = 3.29 \times 10^{15}$ s^{-1}

$\mathcal{R} = 1.097 \times 10^{7}$ m^{-1}

conversions

1 atm = 760 torr

1 atm = 101325 Pa

1 atm = 1.01325 bar

1 atm = 14.7 psi

1 bar = 10^5 Pa

1 in = 2.54 cm

1 mi = 5280 ft

1 Å= 10^{-10} m

1 lb = 453.6 g

1 ton = 2000 lbs

1 tonne = 1000 kg

1 gal = 3.785 L

1 gal = 231 in^3

1 fl oz = 29.57 mL

conversions

1 cal = 4.184 J

1 eV = 1.602×10^{-19} J

1 kWh = 3600 J

water data

$C_{s,ice} = 2.09$ J/g °C

$C_{s,water} = 4.184$ J/g °C

$C_{s,steam} = 2.03$ J/g °C

$\rho_{water} = 1.00$ g/mL

$\rho_{ice} = 0.9167$ g/mL

$\rho_{seawater} = 1.024$ g/mL

$\Delta H_{fus} = 334$ J/g

$\Delta H_{vap} = 2260$ J/g

$K_w = 1.0 \times 10^{-14}$

This exam should have exactly 25 questions. Each question is equally weighted at 4 points each. You will enter your answer choices on the virtual bubblehseet after you have finished. Your score is based on what you submit on the virtual bubblesheet and not what is circled on the exam.

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1. Television station KXAN in Austin is known as channel 36. That is in the UHF portion of communication frequencies. To be more specific, their video signal is on a carrier frequency of 603.25 MHz. Which of the following is the matching wavelength for this electromagnetic radiation?

a. 20.8 cm

b. 4.97 m

● c. 49.7 cm

d. 2.08 m

e. 497 μm

Explanation: Use $\lambda = c/\nu$
$= 3 \times 10^8 / 603.25 \times 10^6 = 0.497$ m $= 49.7$ cm

---

2. Identify the set that contains ONLY ionic compounds.

● a. NaBr, Fe_2O_3, $CaCl_2$

b. CH_3CH_2OH, Al_2O_3, CH_4

c. $CaCl_2$, HI, H_2O

d. $CuCl_2$, NaCl, $HClO_3$

e. HCl, AgCl, Al_2O_3

Explanation: Look for a metal bonded to a nonmetal. Remember that hydrogen is not a metal, even though it is positioned in the top left of the periodic table. The correct set is: NaBr, Fe_2O_3, $CaCl_2$.

---

3. What is the electron configuration for the bromide ion (Br^-)?

a. $[Ar]4s^24d^{10}4p^6$

● b. $[Ar]4s^23d^{10}4p^6$

c. $[Ar]4s^23d^{10}4p^4$

d. $[Ar]4s^24p^4$

e. $[Kr]4s^24d^{10}4p^4$

Explanation: Begin at [Ar] and include only the electrons that fill after. This will include the 3d electrons and the one extra electron for the negative charge: $[Ar]4s^23d^{10}4p^6$

---

4. Suppose X stands for a particular element on the periodic table. Select the atom or ion that will have the largest radius.

● a. X^{2-}

b. X^+

c. X^-

d. X^{2+}

e. X

Explanation: Anions becomes larger with the addition of each electron due to electron repulsions in the valence shell. The ion with the greatest negative charge will have the largest radius.

---

5. HBr is a gas that when dissolved in water makes a very strong acid solution. What type of compound is this?

● a. covalent compound

b. ionic compound

Explanation: H and Br are both non-metals. They form a covalent bond which means a covalent compound.

---

6. Which set of p orbitals below has been filled correctly? (they all have 4 electrons)

a. ↑↓ ↑ ↑

b. ↑↓ ↓ ↑

c. ↑↓ ↑↓ __

● d. ↑↓ ↑ ↑

Explanation: According to Hund's Rule, you fill singly before pairing begins. Also you must match the spin state when you do fill singly. So the first 3 electrons go in separate orbitals and they all have up spin (+1/2). The fourth electron pairs with the first and has down spin (-1/2).

---

7. What is the electron configuration of Bismuth (Bi)?

a. [Rn]$6p^3$

● b. [Xe]$6s^2 4f^{14} 5d^{10} 6p^3$

c. [Xe]$6s^2 6p^3$

d. [Rn]$7s^2 5f^{14} 6d^{10} 7p^3$

e. $6s^2 4f^{14} 5d^{10} 6p^3$

f. [Xe]$6s^2 5d^{10} 6p^3$

Explanation: Electronic configurations can be abbreviated using the noble gases on the periodic table to respresent full valence shells. In the case of Bi, the closest previous noble gas is Xe. After the abbreviation, the electronic configuration is filled in by moving from left to right across the periodic table, taking care to not skip over the f-block elements.

---

8. Which of these ionic compounds has the lowest theoretical lattice energy?

a. NaBr

b. CaO

● c. KBr

d. $CaCl_2$

e. $MgCl_2$

Explanation: The lowest lattice energy will involve the lowest chargest and the largest radius. First, you can identify that KBr and NaBr have the lowest charges (+1/-1). Then KBr has the larger radius, making it weaker.

---

9. A common oxidizing agent is $KMnO_4$. What is the name of this oxidizer?

a. sodium manganate

b. potassium magnesium tetraoxide

c. calcium manganous peroxide

d. potassium manganese oxide

● e. potassium permanganate

Explanation: potassium permanganate which is a combo of potassium ion, K^+, and permanganate ion, MnO_4^-.

---

10. Rank the following from smallest to largest atomic radius:

N, Ca, Cs, Sr, F

a. Cs < Sr < Ca < N < F

b. Sr < N < F < Cs < Ca

● c. F < N < Ca < Sr < Cs

d. F < Ca < N < Sr < Cs

e. F < N < Cs < Sr < Ca

Explanation: Atomic radius increases toward the bottom left of the periodic table, corresponding to the order: F < N < Ca < Sr < Cs.

---

11. When we say that two species are isoelectronic with each other, this means that

● a. they have the same exact electron configurations

b. they are on the same row of the periodic table

c. they have the same number of protons

d. they share the same group on the periodic table

e. they have the same charge as ions

Explanation: Isoelectronic means the species have the same exact electron configurations. For common monatomic ions, that electron configuration matches one of the noble gas elements.

---

12. The following species are isoelectronic. Select the atom or ion that will have the largest radius.

- a. S^{2-}
- b. Ar
- c. K^{+}
- d. Ca^{2+}
- e. Cl^{-}

Explanation: Anions becomes larger with the addition of each electron due to electron repulsions in the valence shell. In this isoelectronic series, the sulfur ion has two extra electrons.

---

13. What is the correct formula for magnesium sulfate?

- a. MgS
- b. Mg_2SO_3
- c. $MgSO_4$
- d. $Mg(SO_3)_2$
- e. $Mg(SO_4)_2$

Explanation: Magnesium ion is Mg^{2+} and sulfate is SO_4^{2-} which means they match up in a 1:1 ratio as $MgSO_4$.

---

14. It takes light with a frequency of approximately 2.687×10^{15} Hz to break the triple bond between carbon and oxygen in carbon monoxide. Calculate the energy (in kJ/mol) necessary to break one mole of carbon-oxygen triple bonds.

- a. 4.455×10^{-17} kJ/mol
- b. 1072 kJ/mol
- c. 687.2 kJ/mol
- d. 1.780×10^{-18} kJ/mol
- e. 945.2 kJ/mol

Explanation: $E = h\nu = (6.626 \times 10^{-34})(2.687 \times 10^{15})$

Next scale up by multiplying energy by N_A and divide by 1000 to convert from J/mol to kJ/mol:

$1072 \text{ kJ/mol} = E \times (6.022 \times 10^{23}) \times \frac{1 \text{ kJ}}{1000 \text{ J}}$

---

15. Which element has the largest atomic radius?

- a. S
- b. Br
- c. Ar
- d. P
- e. Sb

Explanation: Atomic radii increase moving down a group(column) on the periodic table and decrease moving to the right across a period(row) on the periodic table. Moving down a row results in a larger increase in atomic radius than moving over 1 element to the left because moving down represents gaining an additional shell of electrons. Moving to the left just eases the contraction that occurs by having an additional electron in the valence shell interacting with the nucleus.

---

16. Which element listed below has the smallest value for ionization energy?

- a. F
- b. He
- c. Cl
- d. I
- e. Br

Explanation: Ionization energy decreases down a group as the valence shell becomes further and further from the nucleus of the atom and in turn the valence electrons become easier to remove. Thus, iodine (I) would have the lowest ionization energy.

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17. You meet Hank Hill, who sells propane and propane accessories. He asks if you, a chemistry student, can tell him the chemical formula of propane.

- a. C_2H_6
- b. C_4H_{10}
- c. C_3H_8
- d. C_4H_8
- e. C_3H_6

Explanation: This is a pure nomeclature problem. Propane is the third alkane, corresponding to 3 carbons. The generic formula for all alkanes is C_nH_{2n+2}.

---

18. Four covalent bonds all involving carbon are listed below. Which one is the most polar in character?

a. C — C

b. C — O

c. C — H

d. C — N

● e. C — F

Explanation: F (fluorine) is the most electronegative element which means the C — F bond is the most polar.

---

19. Which of the following is the correct name for $FeCl_3$?

a. fluorine trichloride

b. iron(III) chlorate

c. iron(IV) chlorite

d. iron trichloride

● e. iron(III) chloride

Explanation: iron(III) chloride

---

20. How many joules of energy are in one photon that has a wavelength of 166 nm?

a. 1.01×10^{-40} J

b. 1.75×10^{-18} J

● c. 1.20×10^{-18} J

d. 3.50×10^{-19} J

e. 5.25×10^{-19} J

Explanation: $E = hc/\lambda$

$= 6.626 \times 10^{-34}(3 \times 10^{8})/166 \times 10^{-9} = 1.2 \times 10^{-18}$ J

---

21. Which color of visible light corresponds to the highest frequency?

a. Green

● b. Blue

c. Red

d. Orange

e. Yellow

Explanation: Blue light is the high energy end of the visible light spectrum. Since higher energy postively correlates with higher frequency, blue light is the high frequency end of the visible light spectrum as well.

---

22. I know one of the following lengths is the actual radius of a nickel atom. Which one is it?

● a. 145 pm

b. 0.145 μm

c. 1.45 nm

d. 0.0145 mm

e. 14.5 Å

Explanation: The whole range of atomic radii is about 50-300 pm.

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23. Household bleach contains sodium hypochlorite, what is the corresponding chemical formula?

a. $NaClO_3$

b. $NaClO_2$

c. Na_2ClO

● d. NaClO

e. $Na(ClO)_2$

Explanation: Hypochlorite is the polyatomic ion ClO^-. To answer this question correctly, you also need to remember it has a -1 charge and that sodium always has a +1 charge as do all the alkali metals (group 1).

---

24. Which subshell contains an electron with the following quantum number set?

$n = 4, \quad \ell = 2, \quad m_\ell = 0, \quad m_s = \frac{1}{2}$

a. 4f

b. 4p

c. 4s

d. 3p

e. 3s

● f. 4d

g. 3d

Explanation: The subshell is determined by the n and ℓ values. $n = 4$ and ℓ provides the shape, which is d when $\ell = 2$.

---

25. What orbital property is the angular momentum quantum number (ℓ) associated with?

● a. shape

b. electron spin

c. valence shell

d. distance from nucleus

e. orientation in space

Explanation: ℓ respresents the shape of the orbital, as determined by the angular nodes. The other answer choices are all associated with specific quantum numbers.

After you are finished and have all your answers circled, go to the front of the room and then use the QR code there to pull up the virtual answer page. Enter the appropriate info plus all your answers - click the SUBMIT button. Make sure you get the confirmation screen and show it to the TA or proctor. After that, turn in your exam and scratch paper. You're free to leave after that.

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