last name   first name   uteid   signature

Periodic Table of the Elements

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.

1. Identify the set that contains ONLY ionic compounds.

• a. $NaBr$, Fe_2O_3, $CaCl_2$

b. HCl, $AgCl$, Al_2O_3

c. $CuCl_2$, $NaCl$, $HClO_3$

d. $CaCl_2$, HI, H_2O

e. CH_3CH_2OH, Al_2O_3, CH_4

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, $CaCl_2$.

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

a. X^+

b. X

c. X^{2+}

• 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.

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

a. $[Xe]6s^26p^3$

b. $6s^24f^{14}5d^{10}6p^3$

• c. $[Xe]6s^24f^{14}5d^{10}6p^3$

d. $[Rn]7s^25f^{14}6d^{10}7p^3$

e. $[Xe]6s^25d^{10}6p^3$

f. $[Rn]6p^3$

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.

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

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

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

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

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

• e. $[Ar]4s^23d^{10}4p^6$

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: $[Ar]4s^23d^{10}4p^6$

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

a. Yellow

b. Orange

c. Red

●d. Blue

e. Green

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.

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6. 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 share the same group on the periodic table

d. they have the same number of protons

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.

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7. Which element has the largest atomic radius?

●a. Sb

b. Ar

c. P

d. Br

e. S

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.

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

a. 14.5 Å

b. 1.45 nm

c. 0.0145 mm

d. 0.145 μm

●e. 145 pm

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

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

N, Ca, Cs, Sr, F

a. Cs < Sr < Ca < N < F

b. F < N < Cs < Sr < Ca

●c. F < N < Ca < Sr < Cs

d. F < Ca < N < Sr < Cs

e. Sr < N < F < Cs < Ca

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

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

a. $Na(ClO)_2$

b. $NaClO_3$

c. Na_2ClO

d. $NaClO_2$

●e. $NaClO$

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).

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11. 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_3H_8

- b. C_4H_8

- c. C_3H_6

- d. C_2H_6

- e. C_4H_{10}

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}.

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

- a. ionic compound

- ● b. covalent compound

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

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

- a. potassium manganese oxide

- b. potassium magnesium tetraoxide

- c. sodium manganate

- d. calcium manganous peroxide

- ● e. potassium permanganate

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

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

- a. $\underline{\uparrow\downarrow}$ $\underline{\downarrow}$ $\underline{\uparrow}$

- b. $\underline{\uparrow\downarrow}$ $\underline{\uparrow\downarrow}$ $\underline{}$

- c. $\underline{\uparrow\uparrow}$ $\underline{\uparrow}$ $\underline{\uparrow}$

- ● d. $\underline{\uparrow\downarrow}$ $\underline{\uparrow}$ $\underline{\uparrow}$

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 ($-1/2$).

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

- ● a. C — F

- b. C — N

- c. C — C

- d. C — O

- e. C — H

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

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

- a. orientation in space

- b. electron spin

- c. distance from nucleus

- ● d. shape

- e. valence shell

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.

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

• a. S^{2-}

b. Ca^{2+}

c. K^+

d. Ar

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.

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

a. $MgCl_2$

b. $CaCl_2$

• c. KBr

d. CaO

e. NaBr

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.

19. 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. 49.7 cm

b. 2.08 m

c. 4.97 m

d. 497 μm

e. 20.8 cm

Explanation: Use $\lambda = c/\nu$

$= 3 \times 10^8 / 603.25 \times 10^6 = 0.497$ m $= 49.7$ cm

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

a. iron trichloride

b. iron(IV) chlorite

• c. iron(III) chloride

d. iron(III) chlorate

e. fluorine trichloride

Explanation: iron(III) chloride

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

a. Cl

b. Br

• c. I

d. F

e. He

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.

22. 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. 687.2 kJ/mol

b. 945.2 kJ/mol

c. 4.455×10^{-17} kJ/mol

• d. 1072 kJ/mol

e. 1.780×10^{-18} 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 kJ/mol $= E \times (6.022 \times 10^{23}) \times \frac{1\,kJ}{1000\,J}$

23. What is the correct formula for magnesium sulfate?

a. $Mg(SO_4)_2$

•b. $MgSO_4$

c. Mg_2SO_3

d. MgS

e. $Mg(SO_3)_2$

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

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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. 4s

b. 3d

c. 4f

d. 3s

•e. 4d

f. 3p

g. 4p

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

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

a. 1.75×10^{-18} J

•b. 1.20×10^{-18} J

c. 1.01×10^{-40} J

d. 5.25×10^{-19} J

e. 3.50×10^{-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

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.

https://mccord.cm.utexas.edu/helium