CHEMISTRY 204
Hour Exam I
February 14, 2019
Dr. D. DeCoste

Name ________**KEY**__________

Signature ______________________________

T.A. __________________________________

This exam contains 23 questions on 11 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the **best** answer to the first 20 questions and enter these on the special answer sheet. Also, **circle your responses** in this exam booklet.

Show all of your work and provide complete answers to questions 21, 22 and 23.

1-20	(60 pts.)	_____________
21	(20 pts.)	_____________
22	(20 pts)	_____________
23	(20 pts.)	_____________
Total	(120 pts)	_____________

Useful Information:
$N_A = 6.022 \times 10^{23}$

$E=hc/\lambda$

$E = -2.178 \times 10^{-18}\ \text{J}\ (Z^2/n^2) = -1312\ \text{kJ/mol}\ (Z^2/n^2)$

$c = 2.998 \times 10^8$ m/s

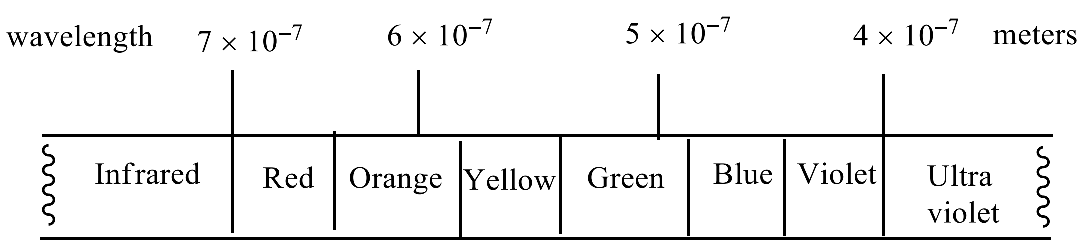
$h = 6.62608 \times 10^{-34}$ Js

$\Delta x \Delta p = h$

$m_e = 9.10939 \times 10^{-31}$ kg

$$E_n = \frac{n^2h^2}{8mL^2} \qquad E = \frac{h^2}{8m}\left[\frac{n_x^2}{L_x^2} + \frac{n_y^2}{L_y^2} + \frac{n_z^2}{L_z^2}\right]$$

1 pm = 10^{-12} m   1 nm = 10^{-9} m



1. Imagine a planet for which the temperature is high enough so that the ground state for a hydrogen electron is $n = 3$. What is the ionization energy (in kJ/mol) for the hydrogen electron on this planet?

a) –1312 b) 0 $\boxed{\text{c) 146}}$ d) 437 e) 1312

2. Consider a hydrogen atom. How many of the following are **true**?

I. A transition of the electron from $n = 5$ to $n = 3$ involves the same energy as a transition from $n = 4$ to $n = 2$.
II. A transition of the electron from $n = 4$ to $n = 2$ will emit radiation of a longer wavelength than one from $n = 5$ to $n = 1$.
III. The wavelength of radiation required to cause the electron to go from energy level n to energy level $n + 1$ decreases with increasing n.
IV. All transitions among the first five energy levels involve radiation in the visible portion of the spectrum.

a) 0 $\boxed{\text{b) 1}}$ c) 2 d) 3 e) 4

3. How many of the following statements are **true**?

I. In a hydrogen (H) atom, the 4*s* orbital is at higher energy than the 3*d* orbital.
II. The Z_{eff} for a 2s electron in uranium (U) is greater than the Z_{eff} for a 2s electron in beryllium (Be).
III. The 1*s* orbital of the lithium (Li) atom is higher in energy than the 1*s* orbital of the hydrogen (H) atom.
IV. The energy of red light is greater than the energy of violet light.

a) 0 b) 1 $\boxed{\text{c) 2}}$ d) 3 e) 4

4. Which of the following has the **shortest wavelength**?

a) An electron traveling at 1% the speed of light.
b) An electron traveling at 10% the speed of light.
c) A baseball traveling at 50 mph.
$\boxed{\text{d) A baseball traveling at 100 mph.}}$
e) All have the same wavelength.

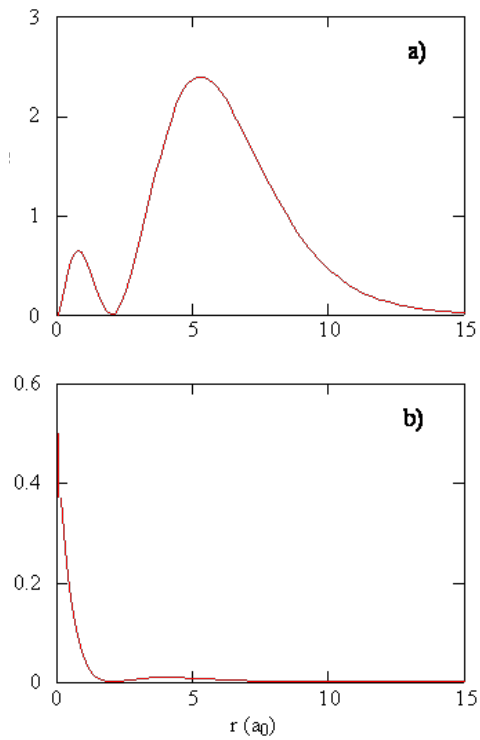
5. Which of the following set of quantum numbers describes an electron with the **highest** energy in an excited hydrogen atom?

a) $n = 3$ $l = 0$ $m_l = 0$
b) $n = 3$ $l = 1$ $m_l = 0$
c) $n = 3$ $l = 1$ $m_l = 1$
d) $n = 3$ $l = 2$ $m_l = 1$
$\boxed{\text{e) Each of the sets above (a-d) describes an electron with the same energy.}}$

6. Consider a ground state quantum particle trapped in a one-dimensional box of length L. The most probable position for the quantum particle is at x =

a) L
$\boxed{\text{b) L/2}}$
c) L/3
d) 0
e) The particle is equally likely to be found anywhere in the box.

7. The plots below are for the same orbital in the hydrogen atom. Which of the following statements correctly describes these plots?



a) The plots are for the 1*s* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).

b) The plots are for the 2*s* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).

c) The plots are for the 2*s* orbital in hydrogen. The top plot is the probability density of the electron (R^2 vs. distance from the nucleus) and the bottom plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus).

d) The plots are for a 2*p* orbital in hydrogen. The top plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus) and the bottom plot is the probability density of the electron (R^2 vs. distance from the nucleus).

e) The plots are for a 2*p* orbital in hydrogen. The top plot is the probability density of the electron (R^2 vs. distance from the nucleus) and the bottom plot is the electron radial probability distribution ($4\pi r^2R^2$ vs distance from the nucleus).

8. What is the expected ground state electron configuration for the most stable ion of bromine in an ionic compound?

a) [Ar] $4s^2 4d^{10} 4p^5$
b) [Ar] $4s^2 3d^{10} 4p^5$
c) [Ar] $4s^2 4d^{10} 4p^6$
d) [Ar] $4s^2 3d^{10} 4f^{14} 4p^5$
e) [Ar] $4s^2 3d^{10} 4p^6$

9. The hybridization of the **central nitrogen atom** in the N_2O molecule is

a) sp
b) sp^2
c) sp^3
d) dsp^3
e) The hybridization can vary depending on the chosen resonance structure of the molecule.

10. Cyanogen chloride is a highly toxic chemical with the formula NCCl (the carbon atom is central). Predict the hybridization for each of the atoms in the molecule.

	N	C	Cl
a)	sp^2	sp	sp^3
b)	sp	sp^2	sp^2
c)	sp^3	sp^2	sp^2
d)	sp^3	sp^3	sp^3
e)	sp	sp	sp^3

11. Compare the ionization energy of the nitrogen (N) atom to the oxygen (O) atom, nitrogen gas (N_2) and the N_2^- ion. In each case, which species has the **highest ionization energy**?

	N vs. O	N vs. N_2	N vs N_2^-
a)	N	N_2	N
b)	O	N_2	N
c)	N	N	N
d)	O	N	N_2^-
e)	N	N_2	N_2^-

12. The F-F bond in $F_2(g)$ is much weaker than the B-B bond in $B_2(g)$. Why is this?

a) The fluorine atom is much more electronegative than the boron atom.
b) The boron atom is smaller than the fluorine atom.
c) According to MO theory, the bond order for F_2 is less than that for B_2.
d) The electron-electron repulsions are greater in F_2 than in B_2.
e) The B-B bond in $B_2(g)$ is nonpolar.

13. Which of the following bonds gets **stronger** if an electron is **added**?

a) B_2 b) O_2^- c) N_2 d) F_2^+ e) All the bonds get weaker.

14. Consider the description: "Two wave functions of similar energy in a given atom overlap to give a new wavefunction that solves the Schrödinger equation. This new wave function is able to overlap with the wavefunction in a different atom to form a molecule."

    This description best describes:

    a) Simple valence bond theory
    b) Localized electron model
    c) Hybridization
    d) Molecular orbital theory
    e) Crystal field theory

15. Which of the following compounds requires the *cis*/*trans* designation when naming?

    a) pentaamminebromocobalt(II) chloride
    b) diamminedichlorocobalt(II) (tetrahedral)
    c) diamminedichloroplatinum(II) (square planar)
    d) $[Co(en)_3]Cl_2$
    e) At least two of the above (a-d) require the *cis*/*trans* designation when naming.

16. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of $AgNO_3$?

    a) $[Cr(NH_3)_3Cl_3]$
    b) $[Cr(NH_3)Cl]NO_3$
    c) $Na_3[CrCl_6]$
    d) $[Cr(NH_3)_6]Cl_3$
    e) At least two of the above will form a precipitate when treated with an aqueous solution of $AgNO_3$.

17. Consider the complex ion $[Co(en)_2Cl_2]^+$, where en = ethylenediamine = $NH_2CH_2CH_2NH_2$. How many geometric isomers and optical isomers does this complex ion exhibit?

	Geometric isomers	**Optical isomers**
a)	0	0
b)	2	2
c)	2	3
d)	3	2
e)	4	4

18. You discover a new ligand (congratulations!) and wish to place it on the spectrochemical series. Which of the following would be a good choice to determine if the ligand were a weak-field or strong-field ligand by determining the number of unpaired electrons?

    a) Cr^{2+} b) V^{2+} c) Ni^{2+} d) Zn^{2+} e) Cu^{+}

19. The complex ions of Zn^{2+} are colorless in solution. The most likely explanation for this is

a) the Zn^{2+} complex ion is paramagnetic.
b) the *d*-orbital splitting in such complexes is outside of the visible region in the spectrum.
c) the *d*-orbital splitting in such complexes allows for the absorbing of all wavelengths in the visible region.
d) the Zn^{2+} ion is a d^{10} ion.
e) only strong-field ligands can bind with the Zn^{2+} ion.

20. Consider the complex ions $[Co(A)_6]^{2+}$, $[Co(A)_6]^{3+}$, $[Co(B)_6]^{2+}$, and $[Co(C)_6]^{3+}$. The ligands A, B, and C are all neutral. The number of unpaired electrons for each of the complex ions (respectively) are found to be 3, 0, 1, 4. Rank the ligands from **strongest field to weakest field.**

a) A, B, C
b) C, B, A
c) B, C, A
d) A, C, B
e) B, A, C