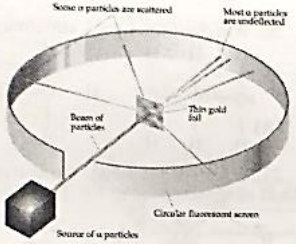
Unit 1 Practice Test Name KEY

MULTIPLE CHOICE – NO CALCULATOR ALLOWED

1. Rutherford's gold foil experiment studied the deflection or scattering of alpha particles, now known as helium nuclei. Most of the alpha particles passed through the foil, but a small number were deflected at very large angles. Which of the following statements represents a structural feature of the atom that was validated by these experiments?



(A) The positive charge is distributed evenly throughout the atom.
(B) Most of the volume of an atom is empty space.
(C) The atomic nucleus contains an equal number of protons and electrons.
(D) The majority of an atom's mass comes from the protons and electrons.
(E) The nucleus is a dense center of mass and negative charge.

2. For which of the following pairs does each atom contain the same number of neutrons?
(A) nitrogen-14 and oxygen-16
(B) silicon-28 and sulfur-32
(C) aluminum-27 and phosphorus-30
(D) neon-22 and magnesium-24

3. Which of the following pairs of ions are isoelectronic?
(A) Mg^{2+} and S^{2-}
(B) Al^{3+} and O^{2-}
(C) F^- and Cl^-
(D) Sc^{3+} and Ti^{2+}

4. The element boron has two naturally occurring isotopes: ^{10}B and ^{11}B. Which of the following represents the most probable data for the relative abundances of these two isotopes?

	Abundance of boron-10	Abundance of boron-11
(A)	20%	80%
(B)	40%	60%
(C)	50%	50%
(D)	80%	20%

5. Which of the following choices has correctly classified all six compounds as being either ionic or covalent?

	Covalent (Molecular) Compound	Ionic Compound
A	SCl_2, CO, NBr_3	$SnCl_2$, CaO, $NiBr_3$
B	~~$SnCl_2$, CaO, $NiBr_3$~~	SCl_2, CO, NBr_3
C	CO, ~~$SnCl_2$~~, NBr_3	CaO, SCl_2, $NiBr_3$
D	~~CaO~~, CO	$SnCl_2$, SCl_2, NBr_3, $NiBr_3$

$c = v\lambda$

6. Two types of electromagnetic radiation, X and Y, are represented in the data table below.

Type of electromagnetic radiation	Frequency (s^{-1})	Wavelength (m)	Energy (J)
X	3×10^{21}	1×10^{-13}	2×10^{-12}
Y	3×10^{14} ↓	? ↑	? ↓

Which of the following are the most probable values for the wavelength and energy associated with Y ?
(A) 1×10^{-20} m, 2×10^{-5} J
(B) 1×10^{-20} m, 2×10^{-19} J
(C) 1×10^{-6} m, 2×10^{-5} J
(D) 1×10^{-6} m, 2×10^{-19} J

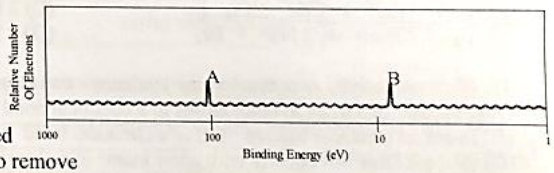
7. Which of the following represents the ground state electron configuration and an excited state electron configuration for the same element?

	Ground State	Excited State
(A)	$1s^2 2s^2 2p^6$	$1s^2 2s^2 2p^6 3s^1$
(B)	$1s^2 2s^2 2p^6$	$1s^2 2s^2 2p^5 3s^1$
(C)	$1s^2 2s^2 2p^6 3s^1$	$1s^2 2s^2 2p^6$
(D)	$1s^2 2s^2 2p^6 3s^2$	$1s^2 2s^2 2p^5 3s^3$

8. There are eight elements located in Period 3 of the periodic table. How many of these elements have a ground state electron configuration that contains exactly two unpaired electrons? Si, S
(A) one
(B) two
(C) three
(D) four

9. When electrons are removed from an atom to form a cation, they are always removed first from the occupied orbitals having the largest principal quantum number (n). Which of the following represents the ground state electron configuration for the V^{3+} ion?
(A) [Ar] $3d^2$
(B) [Ar] $3d^1 4s^1$
(C) [Ar] $4s^2$
(D) [Ar] $3d^6 4s^2$

10. The diagram above represents the photoelectron spectrum for beryllium. Which of the following statements is correct concerning Peak A and Peak B?



(A) The electrons that are represented by Peak A require more energy to remove because they are located in a full orbital.
(B) The electrons that are represented by Peak B require more energy to remove because they are located in a full orbital.
(C) The electrons that are represented by Peak A require more energy to remove because they are closer to the nucleus.
(D) The electrons that are represented by Peak B require less energy to remove because they are located in a half-filled orbital.

Element	Atomic Radius (pm)	First Ionization Energy (kJ/mol)
Calcium	194	590
Potassium	? ↑	? ↓

11. Based on periodic trends and the data in the table above, which of the following are the most probable values of the atomic radius and the first ionization energy for potassium?
(A) 120 pm, 419 kJ/mol
(B) 120 pm, 633 kJ/mol
(C) 242 pm, 419 kJ/mol
(D) 242 pm, 633 kJ/mol

12. Which of the following properties tend to decrease as you move from top to bottom down Group 14 of the periodic table?
(A) atomic radius
(B) 1st ionization energy
(C) metallic character
(D) reactivity with oxygen

Successive Values of Ionization Energy (kJ/mol) for Element X					
I_1	I_2	I_3	I_4	I_5	I_6
578	1817	2745	11575	14830	18376

3 valé

13. Element X is located in Period 3. Based on the information in the table above, what is the most likely identity of element X?
(A) Mg (B) Al (C) Si (D) P

14. Which of the following series is listed in order of decreasing radius?
(A) K^+, K, Rb
(B) Ca^{2+}, Ca, Mg
(C) O^{2-}, O, S
(D) P^{3-}, P, N

15. Based on the trends in chemical reactivity for the alkali metals and the halogens, which of the following reactions should not occur?
(A) $I_2 + 2\,KCl \rightarrow 2\,KI + Cl_2$
(B) $F_2 + 2\,NaBr \rightarrow 2\,NaF + Br_2$
(C) $2\,K + 2\,H_2O \rightarrow 2\,KOH + H_2$
(D) $2\,Na + H_2 \rightarrow 2\,NaH$

16. Electronegativity is defined as the tendency of an atom
(A) to donate electrons to other atoms in a chemical bond
(B) to attract electrons toward itself in a chemical bond
(C) to share electrons equally with other atoms in a chemical bond
(D) in the gaseous state to gain an electron to become an anion.

17. Which of the following compounds contains both ionic and covalent bonds?
(A) zinc selenide
(B) dinitrogen trioxide
(C) magnesium sulfate
(D) iron(II) chloride

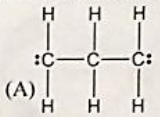
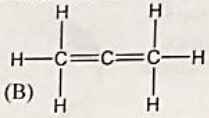
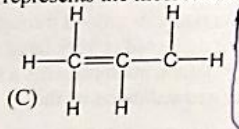
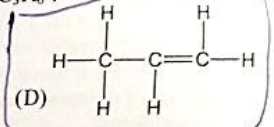
18. Which of the following molecules has a Lewis structure that is identical to NI_3 ?
(A) sulfur trioxide
(B) boron trichloride
(C) chlorine trifluoride
(D) arsenic tribromide

:O–S=O

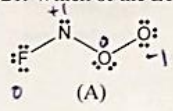
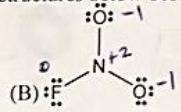
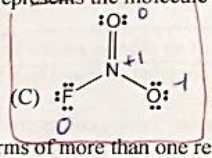
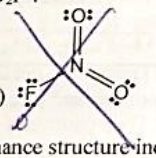
19. Which of the following molecules has a Lewis structure that contains exactly one nonbonding pair of electrons on the central atom?
(A) sulfur dioxide
(B) carbon disulfide
(C) dinitrogen monoxide
(D) oxygen difluoride

N=N–O:

20. Which of the Lewis structures below best represents the molecule C_3H_6 ?

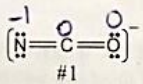
(A) 
(B) 
(C) 
(D) 

21. Which of the Lewis structures below best represents the molecule NO_2F ?

(A) 
(B) 
(C) 
(D) 

22. Polyatomic ions that can be described in terms of more than one resonance structure include
I. nitrate
II. carbonate
III. phosphate
(A) I. only (B) I. and II. only (C) II. and III. only (D) I., II., and III.

23. Of the three Lewis structures for the cyanate ion (NCO^-) shown above, the most favorable (or dominant) structure is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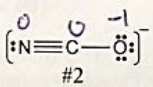
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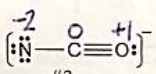
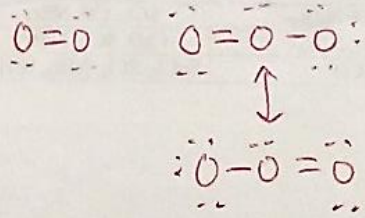
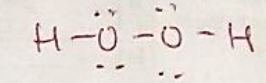

#3

(A) #1, because the lengths of the C–N and C–O bonds are equal to each other
(B) #2, because it places the negative charge on the most electronegative atom
(C) #2, because C–N bonds tend to be stronger and more stable than C–O bonds
(D) #3, because it produces formal charges that have the largest magnitude

24. Which of the following series is listed in order of increasing O–O bond length?
(A) O_2, O_3, H_2O_2
(B) O_3, O_2, H_2O_2
(C) O_2, H_2O_2, O_3
(D) H_2O_2, O_2, O_3





+ 870 | − 1260

150 + 3×240 | 2×3×210

$I_2(g) + 3\,Cl_2(g) \rightarrow 2\,ICl_3(g)$ $\Delta H° = ?$

25. According to the data in the table below, what is the estimated value of $\Delta H°$ for the reaction shown above?

Bond	Average Bond Enthalpy (kJ/mol)
I–I	150
Cl–Cl	240
I–Cl	210

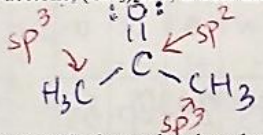
(A) –1260 kJ (B) –390 kJ (C) +180 kJ (D) +240 kJ

26. Which of the following choices represents the correct estimates of the bond angles in methane and water?

	H–C–H bond angle in CH_4	H–O–H bond angle in H_2O
(A)	90°	180°
(B)	109.5°	105°
(C)	109.5°	109.5°
(D)	109.5°	115°

27. Dichloromethane (CH_2Cl_2) is best described as a
(A) polar molecule that contains polar bonds
(B) polar molecule that contains nonpolar bonds
(C) nonpolar molecule that contains polar bonds
(D) nonpolar molecule that contains nonpolar bonds

28. The hybridization of the carbon atoms in acetone, $(CH_3)_2CO$, is best described as
(A) sp^2 for all three carbon atoms
(B) sp^3 for all three carbon atoms
(C) either sp or sp^2
(D) either sp^2 or sp^3



29. Which of the following molecules contains exactly three σ bonds and two π bonds?
(A) C_2H_2
(B) HCN
(C) SO_3
(D) N_2O

H–C≡C–H

FREE RESPONSE – CALCULATOR IS ALLOWED

1. Fill in the table with the missing information. Each Nuclear Symbol should contain the mass number and the charge.

Nuclear Symbol	Charge	Protons	Neutrons	Electrons
$^{115}In^{3+}$	+3	49	66	46
$^{32}P^{3-}$	−3	15	16	18
$^{79}Se^{-2}$	−2	34	45 (34)	36
^{137}Ba	+2	56	81 (56)	54

2. For each name, write the correct formula. Indicate if the substance is ionic or covalent.

Chemical Formula	Name	Ionic (I) or Covalent (C)?
$CoCO_3$	cobalt(II) carbonate	I
$Ba(ClO_3)_2$	barium chlorate	I
N_2O_3	dinitrogen trioxide	C
$(NH_4)_3PO_4$	ammonium phosphate	I
SF_4	sulfur tetrafluoride	C

3. For each formula, write the correct name. Indicate if the substance is ionic or covalent.

Chemical Formula	Name	Ionic (I) or Covalent (C)?
Cl_2O_7	dichlorine heptoxide	C
$Mg(NO_3)_2$	magnesium nitrate	I
K_2S	potassium sulfide	I
PBr_5	phosphorous pentabromide	C
$Pb(C_2H_3O_2)_2$	lead(II) acetate.	I

Element	1st ionization energy (kJ/mol)	2nd ionization energy (kJ/mol)
Sodium	496	4562
Magnesium	738	1451
Potassium	419	3052

6. Use principles of atomic structure to respond to each of the following.

(a) Explain why the 1st ionization energy of sodium is less than the 1st ionization energy of magnesium.

Both valence electrons are in the 3s orbital, but Mg has more protons ∴ its valence electrons experience a stronger effective nuclear charge

(b) Explain why the 1st ionization energy of potassium is less than the 1st ionization energy of sodium.

Potassium's valence electrons are located further away from the nucleus than sodium's. K's 4s electron is more shielded and less tightly held by the nucleus

(c) Explain why the 2nd ionization energy of magnesium is higher than the 1st ionization energy of magnesium.

After the 1st electron is removed, the result is an Mg^+ ion. It requires more energy to remove an electron from a positively charged ion than a neutral atom

(d) Explain why the 2nd ionization energy of sodium is higher than the 2nd ionization energy of magnesium.

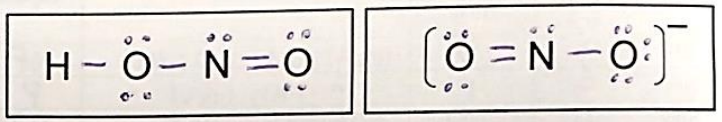
Mg has 2 valence electrons whereas Na only has 1. After the 3s valence electron from Na is removed, the 2nd electron would be removed from the 2p orbital, which would require more energy

(e) Which of the three metals listed in the table above reacts most vigorously with water? Justify your answer based on the information in the table and the reactivity of metals.

Potassium will react most vigorously with water because it has the lowest ionization energy and therefore can lose an electron most easily.

7. Answer the following questions related to nitrous acid (HNO_2) and the nitrite ion (NO_2^-).

(a) Complete the Lewis electron-dot diagrams for HNO_2 and NO_2^- by drawing the required number of electrons, including bonding pairs and nonbonding pairs.



(b) Identify each of the following for the nitrite ion.

(i) Geometry (shape) of the ion: bent

(ii) Hybridization of the nitrogen atom: sp^2

The HNO_2 molecule has been analyzed to determine nitrogen–oxygen bond lengths. The results are listed below.

Nitrogen–Oxygen Bond Lengths in HNO_2 (pm)
118 and 143

(c) Refer to the Lewis structure for HNO_2 that was drawn in part (a). Identify which of the N–O bonds in HNO_2 has a shorter bond length. Justify your answer by discussing the relationship between bond enthalpy and bond length.

The nitrogen that is double-bonded to the oxygen has the shortest bond length. The more bonds, the higher the bond energy and the shorter the bond length

(d) It has been determined that the two N–O bonds in the nitrite ion have the same length. Use principles of chemical bonding to explain this result.

NO_2^- has 2 resonance structures. The nitrite ion molecule behaves as an average of these 2 structures

(e) Estimate the bond length of the N–O bond in the nitrite ion: 130.5 pm

4. Answer the following questions based on the properties of electromagnetic radiation.

(a) A light source emits yellow light with a wavelength of 580 nm. Calculate the frequency of this light in units of s^{-1}. Show your work below in order to receive full credit.

$c = v\lambda$

$(3\times10^{8}\ m/s) = v(580\times10^{-9}\ m)$

$5.2\times10^{14}\ s^{-1}$

(b) Calculate the energy of a single photon of this light in units of joules. Show your work below in order to receive full credit.

$E = h\nu$

$= (6.626\times10^{-34})(\quad)$

3.4×10^{-19} J

(c) The Br–Br bond has a bond energy of 192 kJ/mol. Does light with a wavelength of 580 nm have sufficient energy to break the Br–Br bond? Justify your answer with a calculation. Show your work below in order to receive full credit.

$\frac{3.4\times10^{-19}\ J}{photon} \times \frac{1\ kJ}{1000\ J} \times \frac{6.02\times10^{23}\ ph.}{1\ mol} = 206\ kJ/mol$

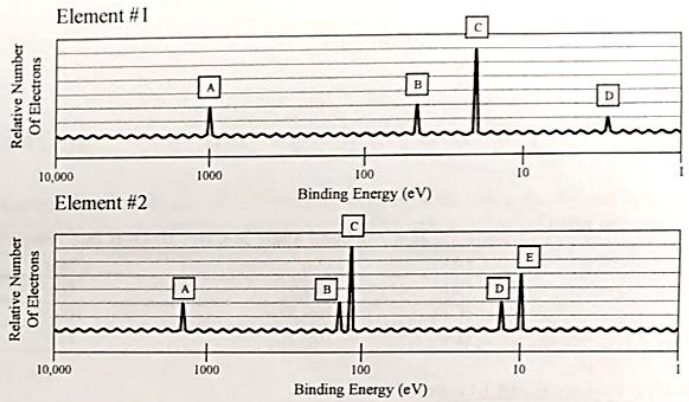
Yes. 206 kJ > 192 kJ

(d) The wavelength of Infrared radiation is (*shorter* | *longer*) than 580 nm.

Therefore, the energy of infrared radiation is (*lower* | *higher*) than the light mentioned in part (a).

It is likely that infrared radiation (*would* | *wouldn't*) have sufficient energy to break the Br–Br bond.

5. Answer the following questions based on the principles of atomic and electronic structure.



(a) The diagrams above represent the photoelectron spectra (PES) for two different elements located in Period 3. Identify Element #1 and Element #2. Label each peak in each PES with the name of the orbital in which the electrons are located. Identify the orbital with its principal quantum number (n) and orbital type, such as 1s or 3p.

Identity of Element #1	A	B	C	D
Na	1s	2s	2p	3s

Identity of Element #2	A	B	C	D	E
S	1s	2s	2p	3s	3p

(b) Explain why peak E is twice as high as peak D in the PES for Element #2.

There are 4 electrons in the 3p orbital, which is twice as many as the number of electrons in the 3s orbital (2)

(c) Explain why peak C has a higher binding energy than peak D in the PES for Element #1.

Electrons in the 2p orbital are closer to the nucleus than the 3s orbital. Electrons in the 2p orbital feel a greater nuclear charge + require more energy to remove an electron

(d) Explain why peak A in Element #2 has a higher binding energy than peak A in Element #1.

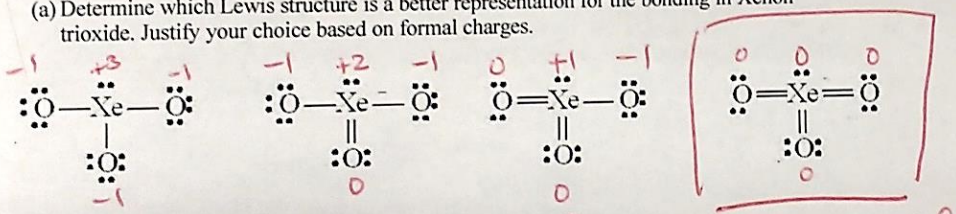
Sulfur has more protons than sodium ∴ the 1s electrons in sulfur feel a greater nuclear charge than sodium & require more energy to be removed.

8. Fill in the missing information in the table below for five different fluoride compounds.

Molecule	Bonding Domains on Central Atom	Nonbonding Domains on Central Atom	Molecular Geometry	Polar or Nonpolar?
BF_3	3	0	trigonal planar	NP
NF_3	3	1	pyramidal	P
SiF_4	4	0	tetrahedral	NP
SF_4	4	1	see-saw	P
XeF_4	4	2	square planar	NP

9. Answer the following questions related to xenon trioxide.

(a) Determine which Lewis structure is a better representation for the bonding in Xenon trioxide. Justify your choice based on formal charges.



all atoms have a formal charge of 0

(b) Identify each of the following for the preferred structure of the xenon trioxide molecule.

(i) Geometry (shape) of the molecule: pyramidal

(ii) Hybridization of the xenon atom: sp^3