This print-out should have 50 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 2.0 points

The second ionization energy of Ti is given by the reaction:

$$Ti^{+}(g) \longrightarrow Ti^{2+}(g) + e^{-}$$

This electron is removed from the:

1. 4p subshell

2. 4d subshell

3. 3s subshell

4. 3d subshell

5. 3p subshell

6. 4s subshell

002 2.0 points

Name the bond in carbon dioxide (CO_2) that forms as a result of head-on overlap on the internuclear axis.

1. σ_{2p-2p}

2. π_{2p-2p}

3. $\pi_{sp^3-sp^3}$

4. $\pi_{sp^2-sp^2}$

5. σ_{sp-sp}

6. σ_{sp-sp^2}

7. $\sigma_{sp^2-sp^2}$

8. σ_{sp^2-2p}

003 2.0 points

When an endothermic reaction has a positive internal energy change for the system,

I. the internal energy of the system is the sum of all energy (potential and kinetic) in the system

II. $\Delta H_{rxn} > 0$

III. there is an overall energy change in the universe

IV. heat enters the system from the surroundings

1. I and IV only

2. I, II, and IV only

3. III and IV only

4. I and II only

5. II only

6. I, II, III and IV

7. I only

004 2.0 points

Rank the following ionic compounds from least to greatest lattice energy:

$CaCl_2$, MgO, $MgCO_3$, NaF

1. $MgCO_3 < CaCl_2 < MgO < NaF$

2. $MgO < NaF < CaCl_2 < MgCO_3$

3. $NaF < CaCl_2 < MgO < MgCO_3$

4. $MgCO_3 < CaCl_2 < NaF < MgO$

5. $NaF < CaCl_2 < MgCO_3 < MgO$

005 2.0 points

Based on the hard sphere model of gases, which of the following gases is most likely to deviate from ideal behavior?

1. Ne

2. Kr

3. Xe

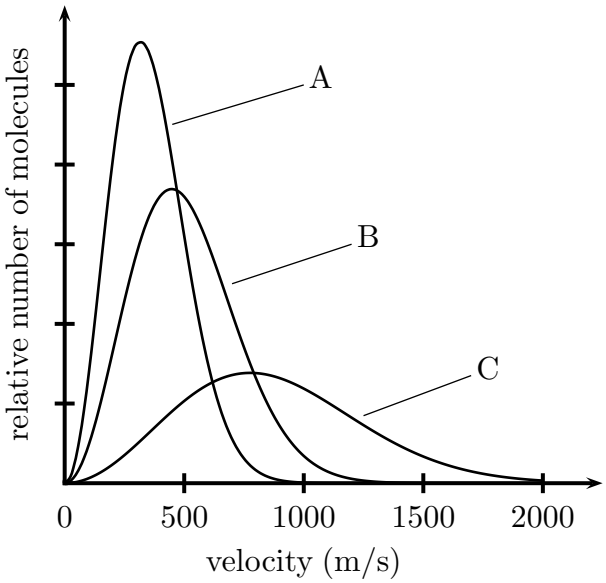
4. Ar

5. He

---

006 2.0 points

The graph shows the approximate Maxwell-Boltzmann distribution plots for three different gases at the same temperature.



Which of the following statements is true?

1. Gas C has the greatest kinetic energy

2. The v_{rms} for Gas A is 1500 m/s

3. Gas B is heavier than Gas A

4. The gas with the highest molecular weight is Gas A

---

007 2.0 points

Rank the following substances in order of vapor pressure: Cl_2, I_2, Br_2, F_2

1. $I_2 < F_2 < Cl_2 < Br_2$

2. $Br_2 < Cl_2 < I_2 < F_2$

3. $F_2 < Cl_2 < Br_2 < I_2$

4. $F_2 < Cl_2 < I_2 < Br_2$

5. $I_2 < Br_2 < Cl_2 < F_2$

---

008 2.0 points

A 5.58 gram gas sample has a volume of 4.15 L, a pressure of 0.78 atm, and a temperature of 311 K. Which of the following gases is it?

1. O_2

2. CO_2

3. Ne

4. SO_2

5. SF_6

6. NH_3

---

009 2.0 points

How many moles are in 63.0 g of $(NH_4)_2Cr_2O_7$?

1. 1.00 mol

2. 4.00 mol

3. 0.500 mol

4. 0.250 mol

---

010 2.0 points

Which set of quantum numbers is possible for an electron in the p subshell found in the ground state of Br?

1. $n = 4, \ell = 1, m_\ell = +1, m_s = -\frac{1}{2}$

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

3. $n = 1, \ell = 1, m_\ell = +2, m_s = -\frac{1}{2}$

4. $n = 4, \ell = 4, m_\ell = +2, m_s = +\frac{1}{2}$

5. $n = 3, \ell = 2, m_\ell = +2, m_s = +\frac{1}{2}$

6. $n = 4, \ell = 2, m_\ell = +1, m_s = -\frac{1}{2}$

---

011 2.0 points

The rate of effusion for carbon monoxide (CO) is ____ times the rate of effusion for xenon (Xe) gas .

1. 2.17

2. 1.59

3. 4.69

4. 3.06

5. 1.16

---

012 2.0 points

A 115 nm beam of light is shined on a gold surface. What is the maximum velocity of the excited electrons? The work function of gold is 5.10 eV.

1. -1000 km/s

2. 1200 km/s

3. 2.001×10^9 km/s

4. 1000 km/s

5. 1×10^6 km/s

6. 1415 km/s

7. No electrons are emitted

---

013 2.0 points

Consider the combustion of propane (C_3H_8) run at constant temperature and pressure:

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

If 2.60 L propane is reacted with 15.6 L oxygen, what is the final volume of all gases?

1. 2.60 L

2. 20.8 L

3. 18.2 L

4. 41.6 L

5. 15.6 L

---

014 2.0 points

Consider the van der Waals equation for non ideal gases. Which of the following statements is true?

1. $(V - nb)$ represents the total volume of the gaseous system

2. Attractions cause the ideal pressure to be greater than the measured (real) pressure

3. $(P + \frac{an^2}{V^2})$ represents the measured pressure

4. This equation can only be used to model ideal gases

5. A large b value correlates with a low molecular weight

---

015 2.0 points

Which of the following molecules is non-polar?

1. PCl_3

2. H_2O

3. BeF_2

4. NH_3

5. CH_3Cl

---

016 2.0 points

Consider the following balanced chemical reaction:

$$2HOCl(g) \rightarrow 2HCl(g) + O_2(g)$$

At a certain temperature, 98.2 grams of hypochlorous acid (HOCl) fully decomposes

to give a final pressure of 680 torr. What is the partial pressure of oxygen in the final reaction system?

1. 680 torr

2. 1020 torr

3. 227 torr

4. 1223 torr

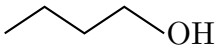
5. 340 torr

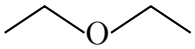
---

017 2.0 points

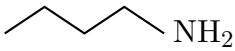
Which of the following has the highest boiling point?

1. 

2. 

3. 

4. 

5. 

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018 2.0 points

Consider the following molecules:

CO, CO_2, CO_3^{2-}

Which molecule has the weakest covalent bonds?

1. All carbon-oxygen bonds have the same strength bonds

2. CO

3. Both CO_3^{2-} and CO_2 have the weakest bonds

4. CO_2

5. CO_3^{2-}

---

019 2.0 points

For which of the following reactions is $\Delta U_{\text{sys}} > \Delta H_{\text{sys}}$ at constant external pressure?

1. $N_2O_5(l) + H_2O(l) \rightarrow 2HNO_3(aq)$

2. $C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$

3. $SnO_2(g) + C(s) \rightarrow Sn(s) + CO_2(g)$

4. $N_2(g) + O_2(g) \rightarrow 2NO(g)$

5. $2NH_3(g) \rightarrow 3H_2(g) + N_2(g)$

---

020 2.0 points

In an acceptable Lewis structure for NO_2^-, what is the formal charge on the central atom?

1. -2

2. None of the above

3. 0

4. +1

5. +2

6. -1

---

021 2.0 points

Arrange the following substances in order from highest to lowest melting point:

C(s, diamond), CH_3CH_2OH, RbF, $MgCO_3$

1. C(s, diamond) > $MgCO_3$ > CH_3CH_2OH > RbF

2. C(s, diamond) > $MgCO_3$ > RbF > CH_3CH_2OH

3. CH_3CH_2OH > $MgCO_3$ > RbF > C(s, diamond)

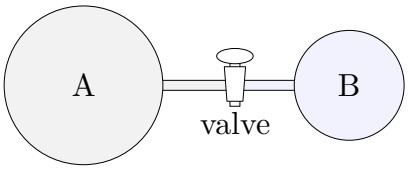
4. C(s, diamond) > RbF > $MgCO_3$ > CH_3CH_2OH

5. CH_3CH_2OH > RbF > $MgCO_3$ > C(s, diamond)

---

022 2.0 points

Consider the diagram shown below of two glass bulbs connected through a valve. The volume for each gas (A and B) is shown under the bulbs and the gases also happen to be at the same temperature (337K) and pressure (685 torr).



51 L 16 L

After the valve is opened, the two gases mix completely. What is the partial pressure of gas A in this new (opened valve) state?

1. 214.9 torr

2. 163.6 torr

3. 521.4 torr

4. 685 torr

5. 2183 torr

---

023 2.0 points

Use bond energy data to determine ΔH_{rxn} for the following reaction:

$CH_4 + 2Cl_2 \rightarrow CCl_4 + 2H_2$

1. 45 kJ/mol

2. -45 kJ/mol

3. -90 kJ/mol

4. −180 kJ/mol

5. 90 kJ/mol

---

024 2.0 points

Which of the following can form hydrogen bonds with another molecule of itself?

I. Ammonia

II. Ethanol

III. CH_3OCH_3

IV. H_2CO

1. I only

2. I, II, III, IV

3. I, III, IV only

4. I, II only

---

025 2.0 points

When a 0.401 g sample of a clean-burning hydrocarbon (molecular weight = 42.05 g/mol) is combusted in a rigid container, the temperature increases from 24.987°C to 28.623°C. The total volume of water is 0.746 L. The sum of all hardware components of the calorimeter have a heat capacity of 2.24 kJ/°C. Calculate the internal energy of combustion for one mole of this hydrocarbon.

1. -19.4936 kJ/mol

2. +2044.15 kJ/mol

3. +3.26600 kJ/mol

4. -3.26600 kJ/mol

5. +8150.74 kJ/mol

6. -2044.15 kJ/mol

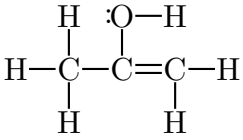
7. +19.4936 kJ/mol

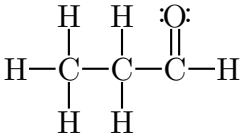
8. +48.6124 kJ/mol

---

026 2.0 points

Which of the following choices is the correct line structure for propionaldehyde, CH_3CH_2CHO?

1.


2.


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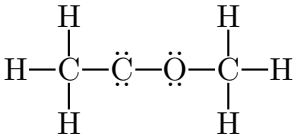
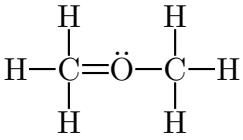
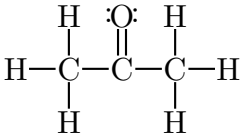
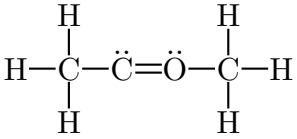
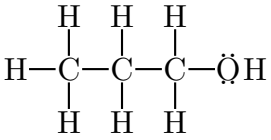


4.


5.


6.


7.


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027 2.0 points

Select the option that correctly lists the substances in order of INCREASING boiling points.

1. None of these places the substances in correct order of increasing boiling points

2. O_2, NH_3, C_2H_6, C_3H_8, H_2O, CaO, NaCl

3. O_2, C_2H_6, C_3H_8, NH_3, H_2O, NaCl, CaO

4. O_2, NH_3, C_3H_8, C_2H_6, NaCl, CaO, H_2O

5. O_2, C_3H_8, C_2H_6, NH_3, H_2O, NaCl, CaO

---

028 2.0 points

Calculate the ΔS_{surr} for the following reaction at 3.0°C and 1 atm.

$CH_3F(\ell) \rightarrow CH_3F(g)$ $\quad \Delta H^\circ_{\text{rxn}} = +16.9$ kJ

1. 61.2 J/K

2. -5.63 J/K

3. −2820 J/K

4. 5630 J/K

5. 5.63 J/K

6. -61.2 J/K

---

029 2.0 points

When a cold gas absorbs white light, you see a continuous absorption spectrum broken by thin black lines in the blue and purple region. Which of the following best describes the emission spectrum of this gas when it is excited with electricity?

1. A continous spectrum broken by black lines shifted to slightly longer wavelengths

2. Mostly black with thin lines in the blue and purple region

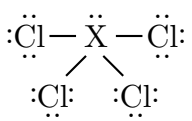
3. Mostly black with thin lines in the yellow and orange region

4. A continuous spectrum broken by black lines in the yellow and orange region

---

030 2.0 points

Consider the following molecule:



What is the identify of the central atom, X?

1. Oxygen

2. Selenium

3. Phosphorus

4. Nitrogen

5. Carbon

6. Chlorine

---

031 2.0 points

The compressibility factor (Z) for a gas at 400 atm is less than one. How can you make an accurate gas law calculation for this gas at 400 atm?

1. This gas can be modeled ideally at this pressure because $PV = nRT$

2. This gas can be modeled ideally at this pressure because $PV < nRT$

3. You must correct for repulsive forces because $PV > nRT$

4. You must correct for attractive forces because $PV < nRT$

5. You must correct for repulsive forces because $PV < nRT$

6. This gas can be modeled ideally at this pressure because $PV > nRT$

7. You must correct for attractive forces because $PV > nRT$

---

032 2.0 points

VSEPR theory can estimate imperfect bond angles based on the fact that

1. bonding regions are more repulsive than lone pair regions

2. bonding regions attract each other while lone pair regions repel each other

3. lone pair regions are more repulsive than bonding regions

4. molecular orbitals hybridize

---

033 2.0 points

Carbon dioxide is a unique substance that sublimes at atmospheric pressure. Assuming no excess heat is supplied to the system at constant pressure, what are the signs of ΔH, ΔS, and w for the following phase change reaction at -78.5°C?

$$CO_2(s) \rightarrow CO_2(g)$$

1. $\Delta H > 0, \Delta S > 0, w > 0$

2. $\Delta H > 0, \Delta S < 0, w < 0$

3. $\Delta H > 0, \Delta S > 0, w < 0$

4. $\Delta H < 0, \Delta S < 0, w = 0$

5. $\Delta H > 0, \Delta S > 0, w = 0$

---

034 2.0 points

Consider the MO diagram for N_2^{2+}. What is the bond order? Is N_2^{2+} paramagnetic or diamagnetic?

1. 2, paramagnetic

2. 1.5, paramagnetic

3. 2.5, paramagnetic

4. 2, diamagnetic

5. 2.5, diamagnetic

6. 1, diamagnetic

7. 1.5, diamagnetic

035 2.0 points

Which of the following terms is path-dependent?

1. Work

2. Heat Capacity

3. Enthalpy

4. Free Energy

5. All of the above

036 2.0 points

What is the wavelength of a 5.80 $\times 10^{14}$ Hz light ray?

1. 789 nm

2. 441 nm

3. 0.666 nm

4. 882 nm

5. 0.792 nm

6. 0.288 nm

7. 992 nm

8. 517 nm

037 2.0 points

Consider the following balanced chemical reaction:

$$H_2SO_4(l) \rightarrow SO_3(g) + H_2O(g)$$

To solve for the ΔH°_{rxn} for this reaction, you collect the following data in the lab:

$H_2S(g) + 2O_2(g) \rightarrow H_2SO_4(l)$,

$\Delta H^\circ_{rxn} = \text{-241.3 kJ/mol}$

$H_2S(g) + 2O_2(g) \rightarrow SO_3(g) + H_2O(l)$,

$\Delta H^\circ_{rxn} = \text{-205.6 kJ/mol}$

$H_2O(l) \rightarrow H_2O(g)$,

$\Delta H^\circ_{rxn} = 41.9$ kJ/mol

What is the ΔH°_{rxn} of the overall balanced reaction?

1. 77.6 kJ/mol

2. 489 kJ/mol

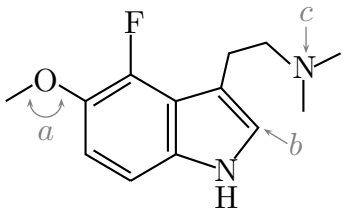
3. -646 kJ/mol

4. 319 kJ/mol

5. -405 kJ/mol

038 (part 1 of 3) 2.0 points

The molecule shown below is a rare alkaloid found in plants native to South America with profound cultural significance.



What is the correct empirical formula for this compound?

1. $C_{13}H_{12}FN_2O$

2. $C_{13}H_{19}FN_2O$

3. $C_{15}H_{17}FN_2O$

4. $C_{12}H_{15}FN_2O$

5. $C_{13}H_{19}N_2O$

6. $C_{13}H_{17}FN_2O$

039 (part 2 of 3) 2.0 points

Which of the following best represents the bond angle labeled a?

1. 109.5°

2. 178°

3. 90°

4. 104.5°

5. 120°

6. 118°

7. 180°

---

040 (part 3 of 3) 2.0 points

What is the electronic geometry around the central atom labeled *b*?

1. Tetrahedral

2. Trigonal pyramid

3. Bent

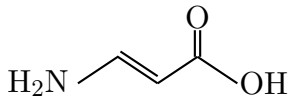
4. Trigonal planar

5. Seesaw

---

041 (part 1 of 2) 2.0 points

Use the following structure to answer the next two questions:



How many sigma and pi bonds are in the organic structure above?

1. 12 σ and 2 π

2. 12 σ only

3. 10 σ and 2 π

4. 10 σ and 4 π

5. 8 σ and 2 π

---

042 (part 2 of 2) 2.0 points

For the structure shown above, what is the hybridization around the carbonyl carbon (i.e. the carbon with the double bond to oxygen)?

1. sp^3

2. sp^3d

3. sp^2

4. sp^3d^2

5. sp

---

043 2.0 points

Consider a reaction that has a negative change in entropy and a negative change in enthalpy. Which of the following conditions will favor spontaneity?

1. This reaction is non-spontaneous at all temperatures

2. This reaction is spontaneous at all temperatures

3. Low Temperatures

4. High Temperatures

---

044 2.0 points

A chemical reaction absorbs 55.3 kJ heat while 16.9 kJ work is done on the system via compression. What is the change in the internal energy (ΔU) for the system?

1. 33.4 kJ

2. 72.2 kJ

3. 67.2 kJ

4. 38.4 kJ

5. 89.1 kJ

6. -38.4 kJ

---

045 2.0 points

A fellow student completes an electron filling

diagram for a ground state atom as shown below:

$3d$ $\underline{\uparrow\downarrow}$ — — — —
$3s$ $\underline{\uparrow\downarrow}$
$2p$ $\underline{\uparrow\downarrow}$ — —
$2s$ $\underline{\uparrow\downarrow}$
$1s$ $\underline{\uparrow\downarrow}$

Understanding that your fellow student's electron filling diagram is not necessarily correct (*i.e.*, the electrons have not necessarily been placed in the correct orbitals), what is the electron configuration for this atom?

1. $1s^2 2s^2 2p^2 3s^2 3d^2$

2. $1s^2 2s^2 2p^6$

3. $1s^2 2s^2 2p^6 3s^2$

4. $1s^1 2s^1 2p^3 3s^1 3d^4$

5. $1s^2 2s^2 2p^3 3s^2 3d^1$

---

046 2.0 points

For which of the following chemical equations would $\Delta H^\circ_{\text{rxn}} = \Delta H^\circ_{\text{f}}$?

1. $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$

2. $C(s, \text{graphite}) + O_2(g) \rightarrow CO_2(g)$

3. $2C(s, \text{diamond}) + O_2(\ell) \rightarrow 2CO(g)$

4. $CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$

5. $4NH_3(g) + 3O_2(g) \rightarrow 2N_2(g) + 6H_2O(g)$

---

047 2.0 points

A closed tube used to transport methane has a volume of 65 L at 320°C and 965 torr. How many moles of gas are in the tube?

1. 2580

2. 6450

3. 1.70

4. 1290

5. 4.31

6. 2.16

7. 1930

8. 12.7

---

048 2.0 points

A 27 mL sample of liquid water at 41°C is frozen and cooled to a final temperature of -18°C. Calculate the heat of this process.

1. −10030 J

2. -543.2 J

3. 13650 J

4. −14670 J

5. 14670 J

---

049 2.0 points

An excited hydrogen electron emits a photon in the Balmer series when it falls from $n = 6$. What is the energy of the photon emitted?

1. 2.44×10^{6} J

2. 4.84×10^{-19} J

3. 2.44×10^{-17} J

4. -4.84×10^{-17} J

5. 4.84×10^{-17} J

6. -2.44×10^{-17} J

---

050 2.0 points

Consider three closed 10L containers at room temperature. Container 1 contains 0.5 moles neon gas. Container 2 contains 0.5 moles argon gas. Container 3 contains 0.5 moles hy-

drogen gas. Which of the following properties, if any, are different between the containers?

I. Average velocity of gas particles

II. Number density

III. Kinetic energy

IV. Pressure

1. I only

2. None of the above

3. I, II, III and IV

4. III only

5. I and III only

6. I and IV only

7. II, III, and IV only

8. II and IV only