Question #1
The graph shows the velocity distribution for five gases at the same temperature. Match each plot in the graph with one of these gases: H$_2$O, O$_2$, N$_2$, He, H$_2$.
Assume ideal gas behavior.

gas 1 is _____
gas 2 is _____
gas 3 is _____
gas 4 is _____
gas 5 is _____

1. _____
2. _____
3. _____
4. _____
5. _____

Question #2
Select all of the following conditions that cause a real gas to act more like an ideal gas.
A. high pressure
B. high temperature
C. low temperature
D. low pressure

Question #3
Which of the following statements is correct for a system that undergoes a change with negative $q$ (heat) and positive $w$ (work)?
A. Work is done by the system while heat is lost to the surroundings.
B. Work is done on the system while heat is lost to the surroundings.
C. Work is done on the system while heat is absorbed by the system.
D. Work is done by the system while heat is absorbed by the system.

Question #4
Calculate the internal energy change for a system that does 422 J of work while losing 227 J of energy as heat.
A. +649 J
B. −649 J
C. −195 J
D. +195 J
Question #: 5
A 10.0 g metal block at 65.0 °C is placed in 50.0 mL of water at 22.0 °C. The final temperature of both is 26.5 °C. The specific heat capacity of the metal is __1__ J/g·°C.
The density of water is 1.00 g/mL.
The specific heat capacity of water is 4.18 J/g·°C.
Report your answer with two significant figures and without units.

1. ______

Question #: 6
The work done (w) when the volume of a system changes from 3.50 L to 2.40 L at a constant pressure of 2.00 atm is __1__ J.
101.3 J = 1.000 L·atm
Report your answer with two significant digits, in the form 2.2E2 or 2.2E-2 if you use scientific notation.

1. ______

Question #: 7
Dissolving 6.00 g of CaCl₂ in 300. mL of water causes the temperature of the solution to increase by 3.43 °C. Determine ΔH for the reaction
CaCl₂(s) →Ca²⁺(aq) + 2 Cl⁻(aq).
The specific heat of the solution is 4.18 J/g·°C
The density of water is 1.00 g/mL.
The calorimeter absorbs no significant amount of heat.

A. –79.6 kJ
B. 79.6 kJ
C. 44.0 kJ
D. –44.0 kJ

Question #: 8
Select all of the true statements about enthalpy (H) and internal energy (E).

A. Enthalpy change is the heat evolved by a chemical reaction at constant pressure.
B. Enthalpy change is the sum of the heat released and the work performed by a chemical reaction.
C. The internal energy change is the heat evolved by a chemical reaction at constant pressure.
D. The internal energy change is the sum of the heat released and the work performed by a chemical reaction.
Question #: 9
In chemical reactions 1 and 2, reactant (R) is converted to product (P). The figures show the enthalpy of each system as the reaction proceeds towards completion. Identify each reaction as **exothermic, endothermic** or **isothermic** (i.e., no enthalpy change).
Reaction 1 is __1___.
Reaction 2 is __2___.

1. _____ 2. _____

Question #: 10
Calculate $\Delta H_{\text{reaction}}$ for
$\text{Fe}_2\text{O}_3(s) + 3 \text{ CO}(g) \rightarrow 2 \text{ Fe}(s) + 3 \text{ CO}_2(g)$
given
$2 \text{ Fe}(s) + 3/2 \text{ O}_2(g) \rightarrow \text{ Fe}_2\text{O}_3(s) \quad \Delta H = -824.2 \text{ kJ}$
$\text{CO}(g) + 1/2 \text{ O}_2(g) \rightarrow \text{ CO}_2(g) \quad \Delta H = -282.7 \text{ kJ}$
A. $-23.9 \text{ kJ}$
B. $23.9 \text{ kJ}$
C. $-1106 \text{ kJ}$
D. $1106 \text{ kJ}$
E. $-553 \text{ kJ}$
F. $553 \text{ kJ}$

Question #: 11
Acetylene gas, $\text{C}_2\text{H}_2$, is used in welding torches. What is the enthalpy of combustion of acetylene?
$2 \text{ C}_2\text{H}_2(g) + 5 \text{ O}_2(g) \rightarrow 4 \text{ CO}_2(g) + 2 \text{ H}_2\text{O}(g) \quad \Delta H_{\text{rxn}} = ? \text{ kJ}$

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A. $-2514 \text{ kJ}$
B. $-1269 \text{ kJ}$
C. $-1156 \text{ kJ}$
D. $2601 \text{ kJ}$
Question #: 12
Based on their relative frequencies, identify which type of electromagnetic radiation is represented by waves 1, 2, and 3 in the figure at right.
Choose one of these options for each wave:
ultraviolet, X-ray, radio
wave 1 = ___ 1___
wave 2 = ___ 2___
wave 3 = ___ 3___

1. _____
2. _____
3. _____

Question #: 13
A pulse of ultraviolet light emits $2.5 \times 10^{-17}$ J of energy at a wavelength of $9.8 \times 10^{-7}$ m. The pulse consists of ___ 1___ photons of ultraviolet light.
Report your answer with two significant figures, using scientific notation in the format 2.2E2 or 2.2E-2.

1. _____

Question #: 14
Light with three different wavelengths irradiates the surface of cesium metal. Which wavelength causes the emission of an electron with the least amount of kinetic energy?

A. 700 nm
B. 550 nm
C. 400 nm
D. Ejected electrons all have zero kinetic energy.
E. Ejected electrons all have the same amount of kinetic energy.
**Question #:** 15
Which of the following statements is **true** about atomic spectra A and B?

A. Spectra A and B are emission spectra for the same element but at different wavelengths.
B. Spectra A and B are emission spectra for two different elements.
C. Spectra A and B are absorption spectra for two different elements.
D. A is an absorption spectrum and B is an emission spectrum for two different elements.

**Question #:** 16
In a Bohr hydrogen atom, which electronic transition **releases** the **most** energetic photon?

A. $n = 3 \rightarrow n = 1$
B. $n = 4 \rightarrow n = 3$
C. $n = 1 \rightarrow n = 4$
D. $n = 2 \rightarrow n = 1$
E. $n = 5 \rightarrow n = 2$

**Question #:** 17
The de Broglie wavelength of an electron (mass = $9.11 \times 10^{-28}$ grams) traveling at a speed of $2.7 \times 10^6$ m/s is ___ nm.
Report your answer with **two** significant figures, in the form 2.2e2 or 2.2e-2 if you use scientific notation.

1. _____
Question #: 18
Select all of the true statements about quantum numbers.

A. The principal quantum number, \( n \), determines the shape of an orbital.
B. Energy is absorbed when an electron moves from a shell with principal quantum number \( n = 1 \) to one with \( n = 3 \).
C. The angular momentum quantum number, \( l \), determines how many orbitals are in a subshell.
D. The overall size of an orbital increases as the value of principal quantum number, \( n \), increases.

Question #: 19
The \( n = 4 \) principal shell includes a total of ___ orbital(s).
Your answer should be an integer.

1. _____

Question #: 20
The angular momentum quantum number, \( l \), for the orbital shown equals ___.

1. _____

Question #: 21
Select all of the values of \( m_l \) below that are allowed for an electron in a \( d \) orbital.

A. –3
B. –1
C. 0
D. 3

Question #: 22
An electron in an atom has quantum numbers \( n = 4 \) and \( m_l = –1 \).
Select all of the atomic orbitals that this electron may occupy.

A. s orbital
B. p orbital
C. d orbital
D. f orbital
Question #: 23
A Bohr hydrogen atom absorbs a photon with a frequency of $2.74 \times 10^{14}$ Hz when an electron is promoted from the $n = 3$ to the $n = \_\_\_\_\_$ energy level.
Your answer should be an integer.

1. _____

Question #: 24
Select all of the allowed sets of quantum numbers for an electron in an atomic orbital.

A. $n = 0$  $l = 3$  $m_l = 3$
B. $n = 2$  $l = 0$  $m_l = -1$
C. $n = 4$  $l = 3$  $m_l = 2$
D. $n = 3$  $l = 2$  $m_l = -1$

Question #: 25
Select all of the following figures that illustrate a $d$ orbital.

A.  
B.  
C.  
D.  
E.  
**Question #:** 26
Which orbital diagram violates the Pauli exclusion principle?

A.  
```
  2s  2p
  ↑  ↓  ↑  ↑
```

B.  
```
  2s  2p
  ↑  ↓
```

C.  
```
  2s  2p
  ↑  ↓  ↑
```

D.  
```
  2s  2p
  ↑  ↑  ↑
```

**Question #:** 27
The electron configuration for a ground-state aluminum atom is __1__.
Use this format with spaces but no superscripts: 1s2 2s2 2p3...

1. _______

**Question #:** 28
The figure at right represents a lithium atom. The shaded region represents the electron cloud of the 1s orbital.
Electron A is __1__ (shielded from, exposed to) the full charge of the nucleus.
Electron B __2__ (shields, penetrates) the 1s electron cloud.

1. _______

2. _______
**Question #:** 29

Which figure shows the ground-state electron configuration of an oxygen atom?

A.  

```
1s  2s  2p
```

B.  

```
1s  2s  2p
```

C.  

```
1s  2s  2p
```

**Question #:** 30

Visible light is emitted from a hydrogen atom when an electron moves from the \( n = 3 \) level to the \( n = 2 \) level. Light emitted when an electron moves from \( n = 4 \) to \( n = 3 \) is not in the visible region. Is it in the infrared or ultraviolet region of the electromagnetic spectrum? Why?

A. Infrared, because a \( n = 4 \) to \( n = 3 \) transition emits more energy than a \( n = 3 \) to \( n = 2 \) transition.

B. Infrared, because a \( n = 4 \) to \( n = 3 \) transition emits less energy than a \( n = 3 \) to \( n = 2 \) transition.

C. Ultraviolet, because a \( n = 4 \) to \( n = 3 \) transition emits more energy than a \( n = 3 \) to \( n = 2 \) transition.

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**Question #1**
The graph shows the velocity distribution for five gases at the same temperature. Match each plot in the graph with one of these gases: \( \text{H}_2\text{O}, \text{O}_2, \text{N}_2, \text{He}, \text{H}_2 \). Assume ideal gas behavior.

gas 1 is 1

gas 2 is 2

gas 3 is 3

gas 4 is 4

gas 5 is 5

1. \( \text{O}_2\) | oxygen |
2. \( \text{N}_2\) | nitrogen |
3. \( \text{H}_2\text{O} \) | water |
4. \( \text{He} \) | helium |
5. \( \text{H}_2 \) | hydrogen |

---

**Question #2**
Select all of the following conditions that cause a real gas to act more like an ideal gas.

- A. high pressure ✓
- B. high temperature ✓
- C. low temperature
- D. low pressure

---

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Which of the following statements is correct for a system that undergoes a change with negative \( q \) (heat) and positive \( w \) (work)?

- A. Work is done by the system while heat is lost to the surroundings.
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---

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Calculate the internal energy change for a system that does 422 J of work while losing 227 J of energy as heat.

- A. +649 J ✓
- B. −649 J
- C. −195 J
- D. +195 J
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A 10.0 g metal block at 65.0 °C is placed in 50.0 mL of water at 22.0 °C. The final temperature of both is 26.5 °C. The specific heat capacity of the metal is ___ J/g·°C.
The density of water is 1.00 g/mL.
The specific heat capacity of water is 4.18 J/g·°C.
Report your answer with two significant figures and without units.

1. 2.4

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The work done (w) when the volume of a system changes from 3.50 L to 2.40 L at a constant pressure of 2.00 atm is ___ J.
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Report your answer with two significant digits, in the form 2.2E2 or 2.2E-2 if you use scientific notation.

1. 2.2E2

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Reaction 1 is _____.
Reaction 2 is _____.

1. endothermic|Endothermic|ENDOTHERMIC|endo|endothemic|endothemric|
2. exothermic|Exothermic|EXOTHERMIC|exo|exothemic|exothemric|

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Based on their relative frequencies, identify which type of electromagnetic radiation is represented by waves 1, 2 and 3 in the figure at right.
Choose one of these options for each wave:
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- wave 1 = __1__
- wave 2 = __2__
- wave 3 = __3__

1. X-ray|x-ray|xray|Xray|x|X|
2. Ultraviolet|UV|
3. radio|radoi|radio wave|radio waves|radiowave|radiowaves|

**Question #**: 13
A pulse of ultraviolet light emits $2.5 \times 10^{-17}$ J of energy at a wavelength of $9.8 \times 10^{-7}$ m. The pulse consists of ___1___ photons of ultraviolet light.
Report your answer with two significant figures, using scientific notation in the format 2.2E2 or 2.2E-2.

1. 123|124|122|121|120|125|126|1.2E2|1.2 E 2|

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Light with three different wavelengths irradiates the surface of cesium metal. Which wavelength causes the emission of an electron with the least amount of kinetic energy?

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B. n = 4 → n = 3
C. n = 1 → n = 4
D. n = 2 → n = 1
E. n = 5 → n = 2

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Report your answer with two significant figures, in the form 2.2e2 or 2.2e-2 if you use scientific notation.

1. 2.7|0.27|2.7e-1|2.6|2.5|2.6e-1|2.7e-1|2.6E-1|2.5E-1|0.26|0.25
Question #: 18
Select all of the true statements about quantum numbers.

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B. Energy is absorbed when an electron moves from a shell with principal quantum number \( n = 1 \) to one with \( n = 3 \).
C. The angular momentum quantum number, \( l \), determines how many orbitals are in a subshell. ✓
D. The overall size of an orbital increases as the value of principal quantum number, \( n \), increases.

Question #: 19
The \( n = 4 \) principal shell includes a total of 1 orbital(s).
Your answer should be an integer.

1. 16|sixteen|

Question #: 20
The angular momentum quantum number, \( l \), for the orbital shown equals 1.

1. 1|one|

Question #: 21
Select all of the values of \( m_l \) below that are allowed for an electron in a \( d \) orbital.

A. –3 ✓
B. –1 ✓
C. 0 ✓
D. 3

Question #: 22
An electron in an atom has quantum numbers \( n = 4 \) and \( m_l = –1 \).
Select all of the atomic orbitals that this electron may occupy.

A. s orbital ✓
B. p orbital ✓
C. d orbital ✓
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A Bohr hydrogen atom absorbs a photon with a frequency of $2.74 \times 10^{14}$ Hz when an electron is promoted from the $n = 3$ to the $n = \_\_\_\_\_\_\_\_\_$ energy level.
Your answer should be an integer.

1. 6|six|

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Select all of the **allowed** sets of quantum numbers for an electron in an atomic orbital.

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B. $n = 2 \quad l = 0 \quad m_l = -1$
✓ C. $n = 4 \quad l = 3 \quad m_l = 2$
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Select all of the following figures that illustrate a $d$ orbital.

✓ A.  

B.  

✓ C.  

D.  

✓ E.  
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A. 

\[
\begin{array}{c}
\text{2s} \\
\uparrow \\
\downarrow \\
\text{2p} \\
\end{array}
\]

B. 

\[
\begin{array}{c}
\text{2s} \\
\uparrow \\
\text{2p} \\
\end{array}
\]

C. 

\[
\begin{array}{c}
\text{2s} \\
\uparrow \\
\downarrow \\
\text{2p} \\
\end{array}
\]

D. 

\[
\begin{array}{c}
\text{2s} \\
\uparrow \\
\uparrow \\
\text{2p} \\
\end{array}
\]

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The electron configuration for a ground-state aluminum atom is __1___.
Use this format with spaces but no superscripts: 1s2 2s2 2p3...

1. 1s2 2s2 2p6 3s2 3p1 [Ne] 3s2 3p1

Question #: 28
The figure at right represents a lithium atom. The shaded region represents the electron cloud of the 1s orbital.
Electron A is __1__ (shielded from, exposed to) the full charge of the nucleus.
Electron B __2__ (shields, penetrates) the 1s electron cloud.

1. shielded from | shielded | shield |
2. penetrates | penetrate |
Question #: 29

Which figure shows the ground-state electron configuration of an oxygen atom?

✓ A.

B.

C.

Question #: 30

Visible light is emitted from a hydrogen atom when an electron moves from the $n = 3$ level to the $n = 2$ level. Light emitted when an electron moves from $n = 4$ to $n = 3$ is not in the visible region. Is it in the infrared or ultraviolet region of the electromagnetic spectrum? Why?

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C. Ultraviolet, because a $n = 4$ to $n = 3$ transition emits more energy than a $n = 3$ to $n = 2$ transition.

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