Instructions:

⚠️ You will have the entire period to complete the test (70 min)

⚠️ The test is made up of 4 sections:
  o Section A – Multiple Choice / True and False
  o Section B – Matching
  o Section C – Short Answer
  o Section D – Long Answer

⚠️ Please follow all instructions, which are indicated by the flask bullets

⚠️ Please read all questions carefully

⚠️ A mark breakdown of the test can be found on the next page

⚠️ Write your name on the top of every page and Good Luck!
## Mark Summary

<table>
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<tr>
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**TOTAL**

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</table>
Section A – Multiple Choice

Please read each question carefully and then circle the letter of the response that you feel is the most correct. (Approx. 10 min for multiple choice section – 1 min/question)

1) What are the top four gaseous components of our atmosphere (by percentage)?
   [ 1/k/U]
   A. Nitrogen, Oxygen, Hydrogen, Ozone
   B. Nitrogen, Oxygen, Carbon Dioxide, Helium
   C. Nitrogen, Oxygen, Argon, Hydrogen
   D. Nitrogen, Oxygen, Argon, Carbon Dioxide

2) What is the correct balanced chemical equation?
   [ 1/k/U]
   A. H_2(g) + \frac{1}{2} O_2(g) \rightarrow H_2O(g)
   B. 3 H_2(g) + O_2(g) \rightarrow 3 H_2O(g)
   C. 2 H_2(g) + O_2(g) \rightarrow H_2O(g)
   D. H_2(g) + O_2(g) \rightarrow H_2O(g)

3) Standard conditions of temperature and pressure (STP) are taken to be?
   [ 1/k/U]
   A. 25°C 760 mmHg
   B. 298 K 1 atm
   C. 273 K 1 atm
   D. 0°C 76 mmHg

4) Given the units for pressure (atm), temperature (K), volume (L) and amount (mol) of a gas, what are the units for the gas constant (R) in the equation PV = nRT?
   [ 1/k/U]
   A. L^{-1} atm^{-1} mol^{-1} K^{-1}
   B. L atm mol^{-1} K^{-1}
   C. L^{-1} atm mol^{-1} K^{-1}
   D. L atm^{-1} mol^{-1} K^{-1}
5) What are the three types of motion that gas molecules are capable of?  
A. Angular, Rotational, Linear  
B. Linear, Vibrational, Angular  
C. Translational, Vibrational, Rotational  
D. Rotational, Vibrational, Angular

6) As the temperature of a gas increases the gas molecules will increase in?  
A. Potential Energy  
B. Kinetic Energy  
C. Electrical Energy  
D. Total Energy

7) What statement best describes Boyle’s Law?  
A. The volume of a fixed amount of gas at constant pressure is directly proportional to the temperature  
B. At a fixed temperature and pressure, the volume of a gas is directly proportional to the amount of gas  
C. For a fixed amount of gas at a constant temperature, gas volume is inversely proportional to gas pressure  
D. The temperature of a gas is directly proportional to the average translational kinetic energy of its molecules

8) A 72.8 L constant volume cylinder containing 1.85 mol of He is heated until the pressure reaches 3.50 atm. What is the final temperature in degrees Celsius?  
A. 1.41 x 10^3 °C  
B. 1.41 x 10^{-3} °C  
C. 1.41 x 10^2 °C  
D. 1.41 x 10^{-2} °C
9) You have a fixed amount of O\textsubscript{2} gas with a volume of 2.0 L at constant pressure. The gas has an initial temperature of 293 K. If the gas is heated to 353 K, what will the new volume of the O\textsubscript{2} gas be (to the nearest decimal point)?

A. 2.7 L  
B. 3.0 L  
C. 2.0 L  
D. 2.4 L

10) The picture on the right represents a steel tank filled with hydrogen gas at 20\degree C and 3 atm. Which of the diagrams below would best illustrate the tank if the temperature were lowered to -20\degree C (Hydrogen freezes at -259\degree C)?

A.  
B.  
C.  
D.  

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Section A – True/False

⚠ Please read the statements below and then indicate whether they are true or false by circling either true or false. (Approx. 5 min for true/false section – 1 min/question)

1) The kinetic energy of gas molecules is lower than liquid molecules.
   True False

2) 1 mol of gas at STP will have a volume of 22.4 L.
   True False

3) If the pressure of a fixed amount of gas at constant temperature is doubled the volume of that gas will also double.
   True False

4) Hydrogen gas will react with oxygen gas in a 1:2 ratio to produce water (in the gaseous state).
   True False

5) This graph below depicts Charles’s Law; the dotted line extending from the bottom left end of the red line represents a hypothetical gas that does not freeze. Assuming that all gases are hypothetical and do not freeze they would all have the same starting point on the graph.
   True False

[Graph of Charles’s Law with dotted line extending from bottom left]
Section B – Matching

You can rearrange and/or manipulate the ideal gas law equation \((PV = nRT)\) to solve for all the unknowns in column I. Place the letter of the derived gas law equation from column II beside the appropriate unknown in column I. (Approx. 5 min for matching section)

<table>
<thead>
<tr>
<th>Column I</th>
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</thead>
<tbody>
<tr>
<td>Molar Mass (M)</td>
<td>A. ( \frac{nRT}{P} )</td>
</tr>
<tr>
<td>Density (D)</td>
<td>B. ( \frac{PV}{nR} )</td>
</tr>
<tr>
<td>Mass (m)</td>
<td>C. ( \frac{mRT}{PV} )</td>
</tr>
<tr>
<td>Temperature (T)</td>
<td>D. ( \frac{nRT}{V} )</td>
</tr>
<tr>
<td>Moles (n)</td>
<td>E. ( \frac{MP}{RT} )</td>
</tr>
<tr>
<td>Volume (V)</td>
<td>F. ( \frac{MPV}{RT} )</td>
</tr>
<tr>
<td></td>
<td>G. ( \frac{PV}{RT} )</td>
</tr>
<tr>
<td></td>
<td>H. ( \frac{PV}{nT} )</td>
</tr>
</tbody>
</table>

Hue discovers the element of surprise...
Section C – Short Answer

⚠️ Answer the following questions in the space provided. Please be sure to show complete answers. (Approx. 20 min for short answer section)

1) You purchase a bag of potato chips at the beach snack stand for your picnic in the mountains. At the picnic the bag has inflated to the point of bursting. Use your knowledge of gas behaviour to explain, assume temperature is constant. [4 marks: 2 mark for (grammar/spelling/logical drawing), 2 marks for reasoning]

2) A 35.8 L cylinder of Ar (g) is connected to an empty 1875 L tank. If the temperature is held constant and the final pressure is 721 mmHg, what must have been the original gas pressure in the cylinder in atmospheres? Use the G.U.E.S.S. method. [3 marks: 1 mark for G.U., 1 mark for E.S., 1 mark for S.]
3) A 12.8 L cylinder contains 35.8 g O₂ at 46°C. What is the pressure of this gas, in atmospheres? Use the G.U.E.S.S. method. (R = 0.082057 L atm mol⁻¹ K⁻¹)
[4 marks: 2 mark for G.U., 1 mark for E.S., 1 mark for S.]

Section D – Long Answer

⚠️ Read the questions carefully and then provide your answer in the spaces provided.
(Approx. 20 min for long answer section)

a) Explain how an ordinary drinking straw in a glass of pop works in regards to pressure? You may use a diagram or words to explain.
[5 marks: 2 mark for logical diagram or correct grammar/spelling and arrangement, 3 marks for explanation]
b) What could you do to the straw so that you would no longer be able to drink the pop? Explain. [5 marks: 2 mark for grammar/spelling/arrangement, 3 marks for explanation]


c) Diet coke is less dense than regular coke, show the relationship between height of the straw (h) and density of the liquid (d) at constant pressure (P) and gravity (g), to show what type of pop could be pushed up a longer straw.
[3 marks: 1 mark for correct pop, 1 mark for equation, 1 mark for stating the relationship]

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<th>Brand of pop that travels higher.</th>
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<tr>
<td>Equation for height of straw using pressure, density and gravity.</td>
<td>h = [ /1A]</td>
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<tr>
<td>Relationship between height and density at constant pressure.</td>
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**TOTAL**

### Comments:


Section A – Multiple Choice

Please read each question carefully and then circle the letter of the response that you feel is the most correct. (Approx. 10 min for multiple choice section – 1 min/question)

1) What are the top four gaseous components of our atmosphere (by percentage)?
   [1 mark]
   A. Nitrogen, Oxygen, Hydrogen, Ozone
   B. Nitrogen, Oxygen, Carbon Dioxide, Helium
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   D. Nitrogen, Oxygen, Argon, Carbon Dioxide
   D. Nitrogen, Oxygen, Argon, Carbon Dioxide

2) What is the correct balanced chemical equation?
   [1 mark]
   A. \(H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(g)\)
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   C. \(2H_2(g) + O_2(g) \rightarrow H_2O(g)\)
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   [1 mark]
   A. 25°C 760 mmHg
   B. 298 K 1 atm
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4) Given the units for pressure (atm), temperature (K), volume (L) and amount (mol) of a gas, what are the units for the gas constant \(R\) in the equation \(PV = nRT\)?
   [1 mark]
   A. L\(^{-1}\) atm\(^{-1}\) mol\(^{-1}\) K\(^{-1}\)
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   C. L\(^{-1}\) atm mol\(^{-1}\) K\(^{-1}\)
   D. L atm\(^{-1}\) mol\(^{-1}\) K\(^{-1}\)
5) What are the three types of motion that gas molecules are capable of? [1 mark]

A. Angular, Rotational, Linear
B. Linear, Vibrational, Angular
C. **Translational, Vibrational, Rotational**
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6) As the temperature of a gas increases the gas molecules will increase in? [1 mark]

A. Potential Energy
B. **Kinetic Energy**
C. Electrical Energy
D. Total Energy


A. The volume of a fixed amount of gas at constant pressure is directly proportional to the temperature
B. At a fixed temperature and pressure, the volume of a gas is directly proportional to the amount of gas
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8) A 72.8 L constant volume cylinder containing 1.85 mol of He is heated until the pressure reaches 3.50 atm. What is the final temperature in degrees Celsius? [1 mark]

A. 1.41 x 10^3 °C
B. 1.41 x 10^{-3} °C
C. 1.41 x 10^2 °C
D. 1.41 x 10^{-2} °C
9) You have a fixed amount of \( \text{O}_2 \) gas with a volume of 2.0 L at constant pressure. The gas has an initial temperature of 293 K. If the gas is heated to 353 K, what will the new volume of the \( \text{O}_2 \) gas be (to the nearest decimal point)?

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B. 3.0 L  
C. 2.0 L  
D. 2.4 L  

[1 mark]

10) The picture on the right represents a steel tank filled with hydrogen gas at 20°C and 3 atm. Which of the diagrams below would best illustrate the tank if the temperature were lowered to -20°C (Hydrogen freezes at -259°C)?

A.  
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[1 mark]

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<tr>
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<td>9</td>
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<td>10</td>
<td>A</td>
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Section A – True/False

⚠️ Please read the statements below and then indicate whether they are true or false by circling either true or false. (Approx. 5 min for true/false section – 1 min/question)

1) The kinetic energy of gas molecules is lower than liquid molecules. True  
False [1 mark]

2) 1 mol of gas at STP will have a volume of 22.4 L. True  
False [1 mark]

3) If the pressure of a fixed amount of gas at constant temperature is doubled the volume of that gas will also double. True  
False [1 mark]

4) Hydrogen gas will react with oxygen gas in a 1:2 ratio to produce water (in the gaseous state). True  
False [1 mark]

5) This graph below depicts Charles’s Law; the dotted line extending from the bottom left end of the red line represents a hypothetical gas that does not freeze. Assuming that all gases are hypothetical and do not freeze they would all have the same starting point on the graph. True  
False [1 mark]
### Section B – Matching

You can rearrange and/or manipulate the ideal gas law equation \((PV = nRT)\) to solve for all the unknowns in column I. Place the letter of the derived gas law equation from column II beside the appropriate unknown in column I. (Approx. 5 min for matching section)

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<tr>
<td>[1 mark]</td>
<td>E Density ((D))</td>
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<td>[1 mark]</td>
<td>F Mass ((m))</td>
</tr>
<tr>
<td>[1 mark]</td>
<td>B Temperature ((T))</td>
</tr>
<tr>
<td>[1 mark]</td>
<td>G Moles ((n))</td>
</tr>
<tr>
<td>[1 mark]</td>
<td>A Volume ((V))</td>
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![Element of Surprise Cartoon](http://www.jtrue.com/cartoons/art/low/element_of_surprise.jpg)

[6/6]
Section C – Short Answer

⚠️ Answer the following questions in the space provided. Please be sure to show complete answers. (Approx. 20 min for short answer section)

1) You purchase a bag of potato chips at the beach snack stand for your picnic in the mountains. At the picnic the bag has inflated to the point of bursting. Use your knowledge of gas behaviour to explain, assume temperature is constant. [4 marks: 2 mark for (grammar/spelling/logical drawing/labels), 2 marks for reasoning]

- Pressure decreases at higher altitudes
- Volume increases as Pressure decreases

[2 mark (C)] Spelling/Grammar OR Overall Logical Drawing

2) A 35.8 L cylinder of Ar (g) is connected to an empty 1875 L tank. If the temperature is held constant and the final pressure is 721 mmHg, what must have been the original gas pressure in the cylinder in atmospheres? Use the G.U.E.S.S. method. [3 marks: 1 mark for G.U., 1 mark for E.S., 1 mark for S.]

G: \( V_1 = 35.8 \text{ L} \quad V_2 = 1910.8 \text{ L} \quad (V_2 = 1875 \text{ L} + 35.8 \text{ L}) \quad P_2 = 721 \text{ mmHg} \)

U: \( P_1 = ? \)

E: \( P_1 V_1 = P_2 V_2 \rightarrow P_1 = \frac{P_2 V_2}{V_1} \)

S: \( P_1 = \left( \frac{721 \text{ mmHg}}{1 \text{ atm}} \right) \left( \frac{1875 \text{ L}}{35.8 \text{ L}} \right) \quad (1 \text{ atm} / 760 \text{ mmHg}) \)

\( P_1 = 50.6 \text{ atm} \)

S: \( \therefore \) the original gas pressure in the cylinder was 50.6 atm.
3) A 12.8 L cylinder contains 35.8 g O₂ at 46°C. What is the pressure of this gas, in atmospheres? Use the G.U.E.S.S. method. (R = 0.082057 L atm mol⁻¹ K⁻¹) [4 marks: 2 mark for G.U., 1 mark for E.S., 1 mark for S.]

G: V = 12.8 L  m (O₂) = 35.8 g  T = 46°C = 319 K  M (O₂) = 32 g/mol
R = 0.082057 L atm mol⁻¹ K⁻¹

U: P = ?

E: PV = nRT  \( \Rightarrow \)  PV = mRT / M  \( \Rightarrow \)  P = mRT /MV

S: P = \( \frac{(35.8 \text{ g})(0.082057 \text{ L atm mol}^{-1} \text{ K}^{-1})(319 \text{ K})}{(16 \text{ g/mol})(12.8 \text{L})} \)

\[ P = 2.29 \text{ atm} \]

∴ the pressure of the gas is 2.29 atm.

\[ \text{Section D – Long Answer} \]

⚠️ Read the questions carefully and then provide your answer in the spaces provided. (Approx. 20 min for long answer section)

a) Explain how an ordinary drinking straw in a glass of pop works in regards to pressure? You may use a diagram or words to explain. [5 marks: 2 mark for logical diagram or correct grammar/spelling and arrangement, 3 marks for explanation]

- Person sucks on the straw removing all the air in the straw (no pressure)
- Atmosphere pushes down on drink with constant pressure
- No pressure in the straw the atmospheric pressure pushes the drink up the straw into the person’s mouth

Diagram + Labels OR Spelling/Grammar + Arrangement

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b) What could you do to the straw so that you would no longer be able to drink the pop? Explain. [5 marks: 2 mark for grammar/spelling/arrangement, 3 marks for explanation]

- **Make the straw longer** [1 mark (T)]

- **Once the straw reaches a certain length the liquid (with a certain density)** will not be pushed up the straw by the atmospheric pressure [1 mark (T)]

**Spelling/Grammar and Arrangement** [2 mark (C)]

---

b) Diet coke is less dense than regular coke, show the relationship between height of the straw (h) and density of the liquid (d) at constant pressure (P) and gravity (g), to show what type of pop could be pushed up a longer straw. [3 marks: 1 mark for correct pop, 1 mark for equation, 1 mark for stating the relationship]

| Brand of pop that travels higher. | - Diet Coke travels higher up the straw because it is less dense than coke. [1 mark (K/U)] |
| Equation for height of straw using pressure, density and gravity. | h = \( \frac{P}{d \cdot g} \) [1 mark (A)] |
| Relationship between height and density at constant pressure. | - Height is inversely proportional to density Or - Height increases as density decreases [1 mark (C)] |