

**Applecross Senior High School**

**AECHE 2017**

**Covalent Molecules and Gases**

**Test**

**Time allowed: 55 minutes**

**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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| --- | --- | --- |
| **Section** | **Raw Marks** | **Mark Scored** |
| Part A | /15 | /27 |
| Part B | /40 | /73 |
| Total | /55 | /100 = % |

**Part A: Multiple Choice Questions [15 marks]**

1. Which of the following would have dispersion forces as the **only** intermolecular force present in a pure sample?

1. SO2
2. CS2
3. CH2Cl2
4. CO

2. Which of these gives the correct shape for each of the covalent molecules?

**SO3 HCN F2O**

1. pyramidal linear bent / v-shaped
2. trigonal planar linear bent / v-shaped
3. trigonal planar bent / v-shaped linear
4. pyramidal trigonal planar linear

3. As water evaporates from an **open** container at 40°C, which one of the following is **true**?

(a) The water becomes warmer as the kinetic energy of the liquid water molecules increases.

(b) The water molecules decompose into hydrogen and oxygen molecules.

(c) The water has a constant temperature as molecules return to the surface as fast as they leave it.

(d) The water becomes cooler as the kinetic energy of the liquid water molecules decreases.

4. Hot-air ballooning involves heating the air in a large overhead balloon. Which one of the following statements best explains why the balloon rises as the air is heated?

(a) Heating air decreases the volume it occupies.

(b) Atmospheric pressure decreases with temperature.

(c) The air in the balloon becomes less dense as it is heated.

(d) The pressure in the balloon decreases as it is heated.

5. The boiling points of the first three Group 15 hydrides are shown in the table below.

|  |  |
| --- | --- |
|  | Boiling point (°C) |
| NH3 | -33 |
| PH3 | -88 |
| AsH3 | -63 |

Which of the following statements are correct?

1. NH3 has the strongest dispersion forces
2. All the molecules have dipole-dipole forces
3. NH3 has the strongest intermolecular forces
4. NH3 is the only molecule to have hydrogen bonding
5. AsH3 is the most polar molecule
6. (ii) and (iv) only
7. (i), (ii) and (iv) only
8. (i), (iii) and (iv) only
9. (ii), (iii) and (iv) only

6. Which of the following structural / electron dot diagrams are correct?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| (i) | (ii) | (iii) | (iv) | (v) |
| SO2 | PCl3 | HCN | CH2O | NH3 |
| ••  O – S – O  ••  ••  ••  ••  ••  Cl – P – Cl  l  Cl  ••  ••  ••  ••  ••  ••  ••  ••  •• |  | H – C N  •• | H – C O  l  H  ••  •• | H – N – H  l  H  •• |

1. (iv) and (v) only
2. (i), (ii) and (v) only
3. (i) and (v) only
4. (ii), (iv) and (v) only

7. The following graph shows the kinetic energy distribution of a reacting system at two different temperatures.

Number of particles

T1

T2

Ek

Which of the following statements are correct?

1. At T1 the particles have a lower average kinetic energy
2. T1 represents a lower temperature
3. At T2 the particles have a higher average kinetic energy
4. At T2 there are a greater number of particles present
5. (i) and (iii) only
6. (i), (ii) and (iii) only
7. (ii) and (iv) only
8. (i) and (iv) only

8. In which of the following are the covalent bonds ranked in order of decreasing polarity (i.e. most polar to least polar)?

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| (a) | H-O | > | H-F | > | H-Br | > | H-C |
| (b) | H-C | > | H-Br | > | H-O | > | H-F |
| (c) | H-F | > | H-C | > | H-O | > | H-Br |
| (d) | H-F | > | H-O | > | H-Br | > | H-C |

9. Which of the following statements regarding gas pressure is **not** correct for a given mass of gas?

1. At constant temperature, a decrease in the volume of a gas will increase the pressure
2. Pressure is determined by the number of collisions the gas particles have with the walls of the container
3. At constant volume, an increase in the temperature of a gas will decrease the pressure
4. The volume and pressure of a gas are inversely proportional

10. What physical property of water does the paragraph below describe?

“*Water molecules are strongly attracted to each other through cohesive forces. In liquid water, most molecules are attracted to neighbouring water molecules above, below and on all sides. However, the molecules at the surface of the liquid do not have water molecules above them and are therefore pulled more strongly downwards by the water molecules below them.*”

1. Surface tension
2. Hydrogen bonding
3. Vapour pressure
4. Density

11. Consider the information given in the following table.

|  |  |  |
| --- | --- | --- |
|  | Toluene | Butane-1,4-diol |
| Structural diagram |  |  |
| Molar mass, M (g mol-1) | 92.134 | 90.12 |
| Vapour pressure at 50 °C (kPa) | 12.28 | 0.014 |

Which is the **best** explanation for the difference in vapour pressure of these two compounds?

1. Toluene has a higher molar mass than butane-1,4-diol
2. Butane-1,4-diol has fewer carbon atoms in its structure than toluene
3. Toluene has stronger dispersion forces than butane-1,4,-diol
4. Butane-1,4-diol has stronger intermolecular forces than toluene

12. If the volume of a constant mass of gas is halved at constant temperature, which of the following are **true**?

1. the pressure of the gas would increase
2. the average kinetic energy of the gas would increase
3. the number of collisions between the gas particles would increase
4. (i) only
5. (i) and (iii) only
6. (iii) only
7. (i) and (ii) and (iii)

13. What change(s) occur(s) while a liquid is boiling?

(i) The average kinetic energy of the particles increases.

(ii) The attractive forces between the particles become stronger.

(iii) The spacing between the particles increases.

(a) (i) only

(b) (ii) and (iii) only

(c) (iii) only

(d) (i) and (iii) only

14. Two identical flasks are both at 0°C and 100 kPa pressure. One flask contains carbon

dioxide gas (CO2) and the other flask contains nitrogen gas (N2). Which one of the following

statements about the gases in the two flasks is true?

(a) The average kinetic energy of the CO2 particles is greater than that of the N2 particles.

(b) The average velocity of the particles in the two flasks is the same.

(c) The flasks contain the same mass of gas.

(d) The average kinetic energy of the particles in the two flasks is the same.

15. Formic acid (methanoic acid) is used as a preservative and antibacterial agent, as well as in various cleaning products. It has a boiling point of 101 °C and its structure is shown to the below.

Which of the following substances would be **least** soluble in formic acid?





(d)

**Part B: Extended Answer Questions [40 marks]**

**Show all working and express your answer in scientific notation with the correct number of significant figures for full marks.**

**Question 16 (5 marks)**

When 4.22 g of solid zinc metal is mixed with excess hydrochloric acid, a gas is produced

according to the following equation:

**Zn(s) + 2H+(aq) → Zn2+(aq)  + H2(g)**

(a) How many moles of hydrogen gas will be produced? (3 marks)

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(b) What volume will this hydrogen gas occupy at S.T.P.? (2 marks)

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**Question 17 (8 marks)**

Dry ice is the name given to solid carbon dioxide (CO2). It is often used in theatre productions, because at room temperature dry ice will ‘sublime’ or turn from the solid state directly into a gas. This creates white ‘clouds’ that can be used for various special effects.

(a) A small piece of dry ice was placed in a sealed metal container at room temperature. Explain, in terms of the kinetic theory, why the pressure inside the container would have changed once the piece of dry ice has sublimed and the container had returned to room temperature. (3 marks)

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Under conditions of high pressure and/or low temperature, gases will not behave as ‘ideal gases’.

(b) State one example of how gases vary from the expected behaviour of ideal gases. Explain why this variation occurs. (2 marks)

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(c) A 3.75 L cylinder was storing 5.28 g of a gas at STP. Could the identity of this gas be carbon dioxide? Explain, showing all working. (3 marks)

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**Question 18 (7 marks)**

Consider the information given in the table below.

|  |  |
| --- | --- |
| Dimethylamine | Trimethylamine |
|  |  |
| Boiling point 8 °C | Boiling point -3 °C |

(a) Dimethylamine has the ability to form hydrogen bonds. Explain in detail how hydrogen bonds form and draw a diagram showing these bonds in dimethylamine. (4 marks)

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(b) Explain why trimethylamine has the stronger dispersion forces, but dimethylamine has the higher boiling point. (3 marks)

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**Question 19 (8 marks)**

When scientists are looking for other planets that might support life, they search for those that may have liquid water. Water is one of the main reasons that life can exist on planet Earth.

One of the special properties of water is that its solid form (ice) is less dense than its liquid form.

(a) Explain this property in terms of the structure and bonding present in water, and give an example of how this property of water is essential to the survival of many aquatic life forms found on Earth. (4 marks)

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(b) Complete this table by drawing the structural formula for each of the three gases, representing all valence shell electron pairs either as : or –. In addition, state the shape of the molecule, and indicate whether or not the molecule contains polar bonds or is a polar molecule. (6 marks)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Structural diagram** | **Shape** | **Polar bonds**  **(‘yes’ or ‘no’)** | **Polar molecule (‘yes’ or ‘no’)** |
| N2 |  |  |  |  |
| CO2 |  |  |  |  |
| H2O |  |  |  |  |

**Question 20 (5 marks)**

A 2.80 L sample of a gaseous organic compound at S.T.P. is found to have a mass of 7.00 g.

(a) Calculate the molar mass of the compound. (3 marks)

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(b) Determine the molecular formula of the compound if its general formula is known to be CnH2n. (2 marks)

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**Question 21 (7 marks)**

Hydrogen gas may also be used as a fuel, and reacts with oxygen when ignited to form water according to the reaction below.

**2H2(g) + O2(g)  ⇾ 2H2O()**

(a) Calculate the density of hydrogen gas at STP. (2 marks)

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(b) If 1200 kg of hydrogen gas is ignited in air to form H2O. What volume of oxygen gas will react with this mass of hydrogen at S.T.P.? Your answer must be expressed with the appropriate number of significant figures and must include units. (4 marks)

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(b) Given that air is approximately 20% oxygen by volume, what volume of air would be required to react with 1200 kg of hydrogen gas? (1 mark)

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Alternative questions

**Question 22 (9 marks)**

Five sulfur-containing species are listed below. Each of these species has a different shape.

*sulfite ion hydrogen sulfide carbon disulfide sulfur trioxide sulfate ion*

*SO32- H2S CS2 SO3 SO42-*

(a) In the table below, draw the structural formula for each species next to its corresponding shape. Represent all valence shell electron pairs either as : or –. (5 marks)

|  |  |
| --- | --- |
|  | Structure  (showing all valence electrons) |
| Linear |  |
| Trigonal (triangular) planar |  |
| Tetrahedral |  |
| Pyramidal |  |
| V-shaped / Bent |  |

(b) Which of the molecules would be regarded as non-polar? (1 mark)

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(c) Which of the molecules contains the most polar intramolecular bonds? (1 mark)

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**Question 23 (4 marks)**

1. Calculate the number moles of N2 gas that would occupy a 6.50L container at STP.

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1. What would the mass of this gas be?

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