B.3 Gas laws

Practice Worksheet — name: ________________________ date: _____________

FORMULAS FOR THIS TOPIC

PRESSURE $P = \frac{F}{A}$ AMOUNT OF SUBSTANCE $n = \frac{N}{N_A}$ IDEAL GAS LAW $PV = nRT = Nk_BT$

COMBINED GAS LAW $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$ PRESSURE (KINETIC THEORY) $P = \frac{1}{3}\rho v^2$

INTERNAL ENERGY (MONATOMIC) $U = \frac{3}{2}Nk_BT = \frac{3}{2}nRT$

SECTION A — MULTIPLE CHOICE

A1. A fixed mass of ideal gas is heated at constant volume. Its pressure rises because the molecules:

- (A) Expand and take up more space
- (B) Collide with the walls more often and with greater momentum change
- (C) Repel each other more strongly
- (D) Increase in mass

A2. An ideal gas at 27 °C is heated at constant pressure until its volume doubles. Its new temperature is:

- (A) 54 °C
- (B) 600 K
- (C) 327 °C
- (D) 150 K

A3. A real gas behaves most like an ideal gas at:

- (A) High pressure and low temperature
- (B) High pressure and high temperature
- (C) Low pressure and high temperature
- (D) Low pressure and low temperature

SECTION B — SHORT ANSWER

B1. A diver's air bubble has volume 2.0 cm^3 at a depth where the pressure is 3.0 atm and the temperature 280 K. Find its volume just below the surface, at 1.0 atm and 300 K. [3 marks]

B2. State three assumptions of the kinetic model of an ideal gas. [3 marks]

B3. Calculate the internal energy of 2.0 mol of an ideal monatomic gas at 300 K, and state why this equals its total kinetic energy. [3 marks]

ANSWER KEY

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Section A

A1: Collide with the walls more often and with greater momentum change — Higher temperature means higher average speed: each wall collision transfers more momentum, and collisions come more frequently. Both effects raise the rate of momentum transfer per unit area — which is what pressure is.

A2: 600 K — Charles's law needs kelvin: $T_1 = 300$ K; doubling V at constant P doubles T, giving 600 K (327 °C — note that "54 °C" is the trap for students who double the Celsius value).

A3: Low pressure and high temperature — Ideality requires molecular volume to be negligible compared with the container (low pressure/density) and kinetic energy to swamp intermolecular attractions (high temperature). Near condensation, both assumptions fail.

Section B

B1: $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$: $V_2 = 2.0 \times \frac{3.0}{1.0} \times \frac{300}{280} \approx 6.4\ \text{cm}^3$. The pressure drop dominates; the temperature rise adds a small extra expansion.

B2: Any three of: molecules are point particles whose total volume is negligible compared with the gas volume; no intermolecular forces act except during collisions; collisions are perfectly elastic; molecules move randomly; the duration of collisions is negligible compared with the time between them.

B3: $U = \frac{3}{2} nRT = \frac{3}{2}(2.0)(8.31)(300) \approx 7.5$ kJ. For an ideal gas there are no intermolecular forces, hence no molecular potential energy — internal energy is purely the random translational kinetic energy of the molecules.