Exam Papers Practice

1.2 Reacting Masses & Volumes

Mark Schemes

Course	DP IB Chemistry
Section	1. Stoichiometric Relationships
Topic	1.2 Reacting Masses & Volumes
Difficulty	Medium

To be used by all students preparing for DP IB Chemistry HL
Students of other boards may also find this useful

1

The correct answer is **C** because:

	Steps	Calculation
1	Calculate the **moles** of the gas using the formula: Amount of gas (mol) $= \frac{\text{Volume of gas (dm}^3\text{)}}{22.7\text{dm}^3}$	$\frac{2.27}{22.7} = 0.1$ mol
2	Only 20% of the nitrogen was used	0.1 x 0.20 = 0.020 mol
3	Mass of Ammonia Moles $= \frac{\text{Mass}}{\text{Mr}}$ Re-arrange for mass Mass = moles x M_r	0.020 x 17.04 = 0.34 g
4	Nitrogen is a diatomic molecule so for each molecule of nitrogen 2 ammonia molecules will be produced $N_2 \Rightarrow 2NH_3$	0.34 x 2 = **0.68 g**

2

The correct answer is **B** because:

	Steps	Calculation
1	Balanced symbol equation for the cold reaction	$2NaOH (aq) + Cl_2(g) \rightarrow NaOCl (aq) + H_2O (l) + NaCl (aq)$
2	Calculate the relative formula mass of the compound M_r	22.99 + 16.00 + 35.45 = 74.44
3	Find the moles of the product	The balanced equation shows the ratio of the Cl_2 to NaOCl is 1:1, so 0.10 mol of Cl_2 gives 0.10 mol of the NaOCl
4	Mass of Compound Moles = mass / M_r Re-arrange for mass Mass = moles x M_r	0.10 x 74.44 = **7.44 g**

3

The correct answer is **A** because:

	Steps	Calculation
1	Calculate the relative formula mass (M_r) of compound $Mg(NO_3)_2$	24.31 + (14.01 x 2) + (16.00 x 6) = 148.33
2	Moles of $Mg(NO_3)_2$ Moles = $\frac{Mass}{Mr}$	Moles = $\frac{1.48}{148.33}$ = 0.010 mol
3	Ratio of moles in equation: 2 moles of $Mg(NO_3)_2$ produces 4 moles of NO_2	0.010 x 2 = 0.020 mol
4	Mass of NO_2 Moles = $\frac{Mass}{Mr}$ Re-arrange for mass Mass = moles x M_r	0.02 x 46.01 = **0.92 g**

4

The correct answer is **D** because:

	Steps	Calculation
1	Find the volume of carbon dioxide that 1 mole of X would produce	0.1 mol of X ⇒ 9.08 dm^3 of CO_2 1.0 mol of X ⇒ 90.8 dm^3 of CO_2
2	Find the moles of carbon dioxide using the formula, $\text{moles} = \frac{\text{volume in dm}^3}{22.7\text{dm}^3}$	$\frac{90.8}{22.7\text{dm}^3} = 4.0$ mol
3	Use the number of moles of carbon dioxide to deduce the moles of carbon	1.0 mol C ⇒ 1.0 of CO_2 4.0 mol C ⇒ 4.0 of CO_2
4	Deduce the number of carbon atoms in X	X must contain 4 carbon atoms

5

The correct answer is **B** because:

	Steps	Calculation
1	The molar mass of an element would be found using the formula, $M_r = \frac{\text{mass}}{\text{moles}}$	$M_r = \frac{0.65}{\text{moles}}$
2	The moles of a gas at stp would be found using the formula, moles = $\frac{\text{volume in dm}^3}{22.7\text{dm}^3}$	$\frac{606.9/1000}{22.7}$ $\frac{606.9}{22.7 \times 1000}$
3	The question tells you it is a Group II metal so the reacting ratio is 1:1 $M(s) + O_2(g) \rightarrow 2MO(s)$ From this you can deduce the number of moles	Moles of metal= moles of oxygen = $\frac{606.9}{22.7 \times 1000}$
4	Putting these two terms together in $M_r = \frac{\text{mass}}{\text{moles}}$	$0.65 \div \frac{606.9}{22.7 \times 1000}$ OR $\frac{22.7 \times 1000 \times 0.65}{606.9}$

6

The correct answer is **C** because:

	Steps	Calculation
1	**Mass** of nitrogen in 14 g of fertiliser - you are told it contains 20% nitrogen	$14 \times \frac{20}{100}$ = 2.8 g of N
2	**Moles** of nitrogen Moles = $\frac{\text{Mass}}{M_r}$	$\frac{2.8}{14.01}$ = 0.20 mol
3	**Concentration** of nitrogen Concentration (mol /dm^3) = $\frac{\text{Amount of substance (mol)}}{\text{Volume of solution (dm}^3\text{)}}$	$\frac{0.20}{5}$ = **0.04 mol dm^{-3}**

7

The correct answer is **A** because:

- The ideal gas equation is ***pV = nRT***
  - Where *p* is pressure (Pa), *V* is the volume (m^3), *n* is the number of moles, *R* is the gas constant (8.314 J K^{-1} mol^{-1}), and *T* is the temperature (K)
- The closer the conditions are for ideal behaviour, the more accurate calculations are
- Ideal behaviour is identical particles with no internal structure, no volume, random motion, no intermolecular forces and no loss of momentum in collisions
- At low pressure, a gas minimises contact with other particles (intermolecular force tends towards zero as distance tends towards infinity)
- At high temperatures intermolecular forces are massively outweighed by kinetic energy and any collision between particles is less likely to be inelastic (i.e. lose momentum)

B is incorrect as at low temperatures gases deviate from ideal behaviour

C is incorrect as at high pressures gases deviate from ideal behaviour

D is incorrect as at high pressures and low temperatures gases deviate from ideal behaviour

7

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B is incorrect as at low temperatures gases deviate from ideal behaviour

C is incorrect as at high pressures gases deviate from ideal behaviour

D is incorrect as at high pressures and low temperatures gases deviate from ideal behaviour

8

The correct answer is **B** because:

- **The ideal gas equation is *pV = nRT***
  - Where *p* is pressure (Pa), *V* is the volume (m^3), *n* is the number of moles, *R* is the gas constant (8.314 J K^{-1} mol^{-1}), and *T* is the temperature (K)
- **Rearranged for pressure:**

$$p = \frac{nRT}{V}$$

- **Number of moles of hydrogen:**

$$\text{moles (n)} = \frac{\text{mass(m)}}{\text{molar mass } (M_r)} = \frac{0.96}{2.02}$$

- **Known quantities:**
  - Number of moles; $\frac{0.96}{2.02}$
  - Volume; 7.0×10^{-3} m^3
  - Temperature; 303 K
- **Substitution into the equation:**

$$p = \frac{nRT}{V} = \frac{0.96 \times 8.314 \times 303}{2.02 \times 7.0 \times 10^{-3}} \text{ pa}$$

9

The correct answer is **B** because:

- **The ideal gas equation is *pV = nRT***
  - Where *p* is pressure (Pa), *V* is the volume (m^3), *n* is the number of moles, *R* is the gas constant (8.314 J K^{-1} mol^{-1}), and *T* is the temperature (K)
- **Rearranged for number of moles:** $n = \frac{pV}{RT}$
- **Known quantities:**
  - Pressure; 103000 Pa
  - Volume; 5730 cm^3 = 0.00537 m^3
  - Temperature; 60°C = 333 K
- **Substitution into the equation:**

$$n = \frac{103000 \times 0.00537}{8.314 \times 333}$$

- ***Mass of oxygen, O_2 (M_r = 32):***

mass (m) = moles (n) × molar mass (M_r)

$$= \frac{103000 \times 0.00537}{8.314 \times 333} \times 32.00$$

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The correct answer is **D** because:

- **The ideal gas equation is *pV = nRT***
  - Where *p* is pressure (Pa), *V* is the volume (m^3), *n* is the number of moles, *R* is the gas constant (8.314 J K^{-1} mol^{-1}), and *T* is the temperature (K)
- **Rearranged for temperature:**

$$T = \frac{pV}{nR}$$

- **Known quantities:**
  - Pressure; 1.00×10^5 Pa
  - Volume; 1.247×10^{-3} m^3
  - $\text{moles (n)} = \frac{\text{mass(m)}}{\text{molar mass}(M_r)} = \frac{5.35}{70.90}$
- **Substitution into the equation:**

$$T = \frac{70.90 \times (1.0 \times 10^5) \times (1.247 \times 10^{-3})}{(5.35 \times 8.314)}$$

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The correct answer is **A** because:

- The temperature and number of moles remain constant throughout
- **Boyle's Law:** $P_1V_1 = P_2V_2$
  - Where: P_1 is the initial pressure, V_1 is the initial volume, P_2 is the final pressure, V_2 is the final volume
- **Therefore:**

$$V_2 = \frac{p_1}{p_2} \times V_1$$

- **Known quantities**:
  - Pressure (P_1); 101,000 Pa
  - Pressure (P_2); 2,020,000 Pa
  - Volume (V_1); 200cm^3 = 0.0002m^3
- **Substitution into the equation**

$$V_2 = \frac{101000}{2020000} \times 0.0002 = 0.00001 \text{ m}^3 \text{ or } 10 \text{ cm}^3$$

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The correct answer is **B** because:

- **The ideal gas equation is $pV = nRT$**
  - Where p is pressure (Pa), V is the volume (m^3), n is the number of moles, R is the gas constant (8.314 J K^{-1} mol^{-1}), and T is the temperature (K)
- **Rearranged for number of moles:**

$$n = \frac{pV}{RT}$$

- **Known quantities:**
  - Pressure; 100,000 Pa
  - Volume; 960 cm^3 = 0.00096 m^3
  - Temperature; 20°C = 293 K
- **Substitution into the equation:**

$$n = \frac{100000 \times 0.00096}{8.314 \times 293}$$

- 2 moles of sodium produce 1 mole of H_2 gas therefore double the moles of sodium was used $\left(\frac{100000 \times 0.00096 \times 2}{8.314 \times 293}\right)$
- **Mass of Sodium, Na (M_r = 22.99):**

mass (m) = (n) × molar mass (M_r)

$$= \frac{100000 \times 0.00096 \times 2 \times 22.99}{8.314 \times 293}$$

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The correct answer is **B** because:

- Ideal gas behaviour is seen with identical particles with no internal structure, no volume, random motion, no intermolecular forces and no loss of momentum in collisions
- As the pressure increases the volume decreases, showing the pressure of the gas is **inversely proportional** demonstrated by **Boyle's Law:**

$$P_1V_1 = P_2V_2$$

  - Where: P_1 is the initial pressure, V_1 is the initial volume, P_2 is the final pressure, V_2 is the final volume
- As the pressure increases the chances of inelastic collisions between the particles increases, so the gas behaves non-ideally

A is incorrect as the increase in pressure is not going to make the real gas behave more like an ideal gas

C is incorrect as the particles will not be absorbed by the vessel wall, but they are more likely to collide inelastically

D is incorrect as the gas is behaving less like an ideal gas if it is partially liquified

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The correct answer is **D** because:

- **The ideal gas equation is $pV = nRT$**
    - Where p is pressure (Pa), V is the volume (m^3), n is the number of moles, R is the gas constant (8.314 J K^{-1} mol^{-1}), and T is the temperature (K)
- **Rearranged for number of moles:**

$$n = \frac{pV}{RT}$$

- **Known quantities:**
    - Pressure; = 100kPa = 100,000 Pa
    - Volume; 3 dm^3 = 0.003 m^3
    - Temperature; 25°C = 298 K
- **Substitution into the equation:**

$$n = \frac{100000 \times 0.003}{8.314 \times 298}$$

- **Mass of methane gas:**

$$\text{mass(m)} = \text{moles(n)} \times \text{Molarmass}(M_r)$$

$$= \frac{100000 \times 0.003 \times 16.05}{8.314 \times 298}$$

- So the answer is option **D**

A is incorrect as the volume has been left in dm^3 instead of converting to m^3

B is incorrect as the pressure has been left in kPa instead of converting to Pa

C is incorrect as the temperature has been left in °C instead of converting to Kelvin

Exam tip: make sure you know how the units are converted; pressure Pa, volume m^3, temperature K

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The correct answer is **C** because:

- **The ideal gas equation is $pV = nRT$**
  - Where p is pressure (Pa), V is volume (m^3), n is the number of moles, R is the gas constant (8.314 J K^{-1} mol^{-1}) and T is temperature (K)
- **Rearranged for pressure:**

$$p = \frac{nRT}{V}$$

- **Known quantities:**
  - Volume; 2 dm^3 = 0.002 m^3
  - Temperature; 275°C + 273 = 548 K
  - Number of moles (n) = 1.5 10 $^{-2}$ mol
- **Substitution into the equation:**

$$p = \frac{nRT}{V} = \frac{(1.5 \times 10^{-2}) \times 8.314 \times (275 + 273)}{2.0 \times 10^{-3}}$$

Exam tip: make sure the units are converted; pressure Pa, volume m^3, temperature K

The conversions are

$$1\ m^3 = 1000\ dm^3 = 1{,}000{,}000\ cm^3$$

$$\text{temp in } ^{o}C + 273 = \text{temp in Kelvin}$$