Unit 7 · Gas Laws

HARDER PRACTICE QUESTIONS · ANSWER KEY

Full marks 40

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Spot the error

ANSWER U · 3

She used °C; the combined gas equation needs kelvin: $T_1 = 300$ K, $T_2 = 350$ K.

$V_2 = \dfrac{720 \times 300 \times 350}{300 \times 600} = \mathbf{420\ cm^3}$.

Her answer says the volume more than trebled. But the pressure only fell by a factor of 1.2, and the kelvin temperature rose by a factor of only about 1.17, so the volume can grow by only about $1.2 \times 1.17 \approx 1.4$ times.

MARKING SCHEME

- ✓ The mistake: temperatures in °C, not kelvin.
- ✓ $V_2 = 420$ cm^3.
- ✓ The check: both factors are small (about 1.2 and 1.17), so the volume can't treble.

2 Check the readings

ANSWER A · 4

i. PV = 4,000; 4,000; 4,005; **4,800**; 4,000 kPa cm^3. The reading at 200 kPa doesn't fit. It should have been 4,000 ÷ 200 = **20 cm^3**.

ii. **No.** Air lost through a leak stays lost, so PV would fall and stay low. Here PV goes **up** at 200 kPa, and is back at 4,000 at 250 kPa. It is a misread volume, not a leak.

MARKING SCHEME

- ✓ The five values of PV, about 4,000 except for 4,800.
- ✓ The 200 kPa reading doesn't fit; it should be 20 cm^3.
- ✓ A leak would lower PV, and here it rises.
- ✓ At 250 kPa PV is back at 4,000, so no air was lost: a misreading.

3 Find absolute zero yourself

ANSWER A · 3

i. (74.6 − 58.6) ÷ (100 − 20) = 16 ÷ 80 = **0.2 cm^3 for each 1 °C**.

ii. From 58.6 cm^3 it needs 58.6 ÷ 0.2 = 293 °C of cooling: 20 − 293 = **−273 °C**, absolute zero.

iii. Every real gas turns liquid before it gets there.

MARKING SCHEME

- ✓ 0.2 cm^3 per °C.
- ✓ −273 °C.
- ✓ Real gases turn liquid first.

4 Two flasks

ANSWER A · 3

From the first flask: $P = 150 \times 2.0 \div 5.0 = 60$ kPa. From the second: $P = 50 \times 3.0 \div 5.0 = 30$ kPa.

Total: 60 + 30 = **90 kPa**.

MARKING SCHEME

- ✓ $150 \times 2.0 \div 5.0 = 60$ kPa.
- ✓ $50 \times 3.0 \div 5.0 = 30$ kPa.
- ✓ Final pressure 90 kPa.

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5 From the bottom of a lake

ANSWER A · 4

i. $0.80 + 18 \div 10 = 0.80 + 1.8 =$ **2.6 atm**.

ii. $T_1 = 277$ K, $T_2 = 290$ K. $V_2 = \dfrac{2.6 \times 2.0 \times 290}{277 \times 0.80} =$ **6.8 cm³**.

iii. The pressure: it multiplies the volume by $2.6 \div 0.80 = 3.25$, and the temperature by only $290 \div 277 = 1.05$.

MARKING SCHEME

✓ 2.6 atm at the bottom.
✓ Both temperatures in kelvin, 277 K and 290 K.
✓ $V_2 = 6.8$ cm³.
✓ The pressure matters more: × 3.25 against × 1.05.

6 Work backwards

ANSWER A · 4

i. The distances are in the ratio of the rates: $60 \div 40 = 1.5 = \sqrt{M_X \div 17}$. So $M_X = 17 \times 1.5^2 = 17 \times 2.25 =$ **about 38 g/mol**.

ii. Fair, as a suggestion: 38 is close to 36.5. They differ because the gases are spreading through the air in the tube, jostled by its molecules, and Graham's law holds closely only for a gas escaping through a tiny hole into empty space.

iii. **It stays in the same place.** Both gases go faster, but their rates keep the same ratio, which depends only on the molar masses; the ring only forms sooner.

MARKING SCHEME

✓ $1.5 = \sqrt{M_X \div 17}$.
✓ M_X is about 38 g/mol.
✓ Fair, the difference coming from the air in the tube.
✓ The ring stays where it is, since the ratio of the rates doesn't change.

7 What if?

ANSWER A · 3

i. The same $\frac{1}{2}mv^2$, so v goes as $\sqrt{1/M}$: $500 \times \sqrt{28 \div 2} = 500 \times 3.74 =$ **about 1,870 m/s**.

ii. 327 °C = 600 K, twice 300 K, so the average kinetic energy doubles and the speed grows by $\sqrt{2}$: **about 707 m/s**.

iii. A molecule hits another after only about 70 nanometers, about seven billion times a second, and is sent off in a new direction each time. It wanders; it doesn't travel straight.

MARKING SCHEME

✓ About 1,870 m/s.
✓ About 707 m/s.
✓ It collides billions of times a second and keeps changing direction.

8 Compare two separations

ANSWER U · 3

a. $\sqrt{4 \div 2} =$ **1.41 times**.

b. $\sqrt{352 \div 349} =$ **1.0043 times**.

Each wall changes the mix by very little, because the masses of the two uranium gases are so close; only by passing through thousands of walls, one after another, does the share of uranium-235 build up.

MARKING SCHEME

✓ 1.41 times for hydrogen.
✓ 1.0043 times for uranium hexafluoride.
✓ Each wall makes only a tiny change, so thousands are needed.

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9 Which explanation fits the evidence?

ANSWER HA · 3

Deepak's. A value below 1 means *PV* is less than for an ideal gas: the gas squeezes **more** than Boyle's law says. Only attraction does that, and carbon dioxide's molecules attract each other strongly. A value above 1 means *PV* is more than for an ideal gas: the gas squeezes **less** than Boyle's law says, because its molecules' own volume fills a real part of the space. That is hydrogen's rise, and carbon dioxide's at very high pressure.

MARKING SCHEME

- ✓ Deepak's explanation.
- ✓ Below 1: the gas squeezes more than Boyle's law says, because of attraction.
- ✓ Above 1: it squeezes less, because of the molecules' own volume.

10 Correct the misconceptions

ANSWER U · 3

- Molecules don't get bigger when heated. They move faster, and at constant pressure the gas must spread into a bigger space.
- Collisions are perfectly elastic: no kinetic energy is lost, so the molecules never slow down and the pressure doesn't fall.
- Hydrogen is a real gas: no ideal gas exists. At room temperature and 1 atm it only behaves almost exactly like one.

MARKING SCHEME

- ✓ Molecules move faster; they don't grow.
- ✓ Collisions are elastic: no energy is lost.
- ✓ Hydrogen is a real gas that only comes close to ideal under these conditions.

11 Design a fair test

ANSWER A · 4

i. She changes the gas (helium or air), and measures how much each balloon shrinks with time, from the distance round its middle with the thread and ruler.

ii. Any two: the same kind of balloon; the same size when filled; the same room and temperature; the same times of measuring.

iii. Repeat with several balloons of each gas and take the average.

iv. Helium shrinking faster, by about $\sqrt{29 \div 4} = 2.7$ times. (Helium may beat that, since its small atoms also pass through rubber more easily.)

MARKING SCHEME

- ✓ Changes the gas; measures the shrinking with time.
- ✓ Any two things kept the same.
- ✓ Repeats with several balloons and averages.
- ✓ Helium shrinks faster, about 2.7 times.

12 Think

ANSWER HA · 3

$V_2 = \dfrac{60 \times 300}{280} = 64.3\ \text{m}^3$, so **4.3 m³** is pushed out. That is $4.3 \div 64.3 =$ **about 7%** of the air.

The same happens in a hot air balloon, open at the bottom: warming pushes air out, so the warm air left inside is lighter than the same volume of cool air outside, and the balloon rises.

MARKING SCHEME

- ✓ $V_2 = 64.3\ \text{m}^3$, so $4.3\ \text{m}^3$ is pushed out.
- ✓ About 7% of the air.
- ✓ A balloon's warmed air is pushed out, leaving it lighter than the same volume of cool air.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	0	9	25	6	**40**

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