Weird Chemist

DPP–4 : Percentage Composition

Chapter: Some Basic Concepts of Chemistry

Complete Solution Sheet — Q.1 to Q.16

TYPE 1 : Percentage Composition

Core Formula:

$$\%\text{ of element} = \frac{\text{Total mass of that element in one formula unit}}{M_r \text{ of compound}} \times 100$$

Quick Check: Sum of all element percentages must equal 100%.

Q.1 Find the percentage composition of each element present in glucose ($C_6H_{12}O_6$). The percentage of Carbon is

Explanation

$$M_r(C_6H_{12}O_6) = 6(12) + 12(1) + 6(16) = 72 + 12 + 96 = 180 \text{ g/mol}$$

$$\%\text{ C} = \frac{6 \times 12}{180} \times 100 = \frac{72}{180} \times 100 = \mathbf{40}\%$$

Approach / Analogy

Glucose has molar mass 180 g/mol — a standard value worth memorising. The 6 carbon atoms contribute $6 \times 12 = 72$ g per mole. $72/180 \times 100 = 40\%$. Quick sanity check: 40% C + 6.67% H + 53.33% O = 100%. ✓

Common Mistake

Using atomic mass of C (12) directly as the numerator instead of *total* mass from all 6 carbons ($6 \times 12 = 72$). The formula has **6** carbon atoms, so multiply atomic mass by the subscript: $6 \times 12 = 72$, not just 12.

Answer

(1) 40%

Q.2 The percentage of Hydrogen in glucose ($C_6H_{12}O_6$) is

Explanation

$$\%\text{ H} = \frac{12 \times 1}{180} \times 100 = \frac{12}{180} \times 100 = 6.\overline{6} \approx \mathbf{6.67}\%$$

Approach / Analogy

12 hydrogen atoms in glucose, each with mass 1 g/mol. Total H mass = 12 g per mole. $12/180 \times 100 = 6.67\%$. Even though there are 12 H atoms (the most in terms of count), hydrogen is the *lightest* element so its mass contribution is the smallest.

Common Mistake

Confusing the number of H atoms (12) with the percentage. Having 12 atoms doesn't mean 12% — percentage depends on *mass*, not count. With $M_r = 1$ for H, mass of H = 12 g per mole, giving 6.67%, not 12%.

Answer

(3) 6.67%

Q.3 The percentage of Oxygen in glucose ($C_6H_{12}O_6$) is

Explanation

$$\%\,\text{O} = \frac{6 \times 16}{180} \times 100 = \frac{96}{180} \times 100 = 53.\overline{3} \approx \mathbf{53.33}\%$$

Verification: $40 + 6.67 + 53.33 = 100\%$ ✓

Approach / Analogy

Or use the shortcut: after finding %C and %H, subtract from 100:

$$\%\,\text{O} = 100 - 40 - 6.67 = 53.33\%$$

Oxygen dominates the mass of glucose despite having the fewest atoms (6), because each O atom weighs 16 g/mol — far heavier than H (1) and heavier than C (12).

Answer

(4) 53.33%

Q.4 Find the percentage of calcium in calcium carbonate ($CaCO_3$).

Explanation

$$M_r(\text{CaCO}_3) = 40 + 12 + 3(16) = 40 + 12 + 48 = 100 \text{ g/mol}$$

$$\%\,\text{Ca} = \frac{40}{100} \times 100 = \mathbf{40}\%$$

Approach / Analogy

$CaCO_3$ has the convenient molar mass of exactly 100 g/mol. So the % of each element numerically equals its mass contribution: Ca = 40%, C = 12%, O = 48%. When $M_r = 100$, mass of element = % directly. Clean and memorable.

Common Mistake

Computing % C or % O when the question asks for % Ca. Read the question carefully — it asks for calcium specifically. % Ca = 40%, % C = 12%, % O = 48%.

Answer

(1) 40%

Q.5 Which of the following has maximum percentage of oxygen by mass? [NCERT Pg. 18]

Explanation

Calculate % O for each:

Compound	M_r	% O
H_2O	18	$\frac{16}{18} \times 100 = 88.9\%$
CO_2	44	$\frac{32}{44} \times 100 = 72.7\%$
$CaCO_3$	100	$\frac{48}{100} \times 100 = 48\%$
C_2H_5OH	46	$\frac{16}{46} \times 100 = 34.8\%$

Maximum % O = H_2O = 88.9%

Approach / Analogy

H_2O wins because it's the smallest molecule with just one oxygen. With $M_r = 18$ and oxygen contributing 16, nearly 89% of the mass is oxygen. Bigger molecules dilute the oxygen percentage even if they have more oxygen atoms. Think: one grape in a small bag vs. one grape in a big bag — the fraction is smaller in the big bag.

Common Mistake

Thinking CO_2 wins because it has *two* oxygen atoms. More atoms doesn't mean higher *percentage by mass*. The denominator (total M_r) also increases. H_2O has one oxygen but is so light overall that oxygen dominates its mass.

Answer

(1) H_2O

Q.6 Which of the following has maximum percentage of nitrogen by mass?

Explanation

Calculate % N for each compound:

Option	Compound	M_r	% N
(1)	Morphine: $C_{17}H_{19}NO_3$	285	$\frac{14}{285} \times 100 = 4.91\%$
(2)	Heroin: $C_{21}H_{23}NO_5$	369	$\frac{14}{369} \times 100 = 3.79\%$
(3)	LSD: $C_{20}H_{25}N_3O$	323	$\frac{42}{323} \times 100 = 13.00\%$
(4)	Phencyclidine: $C_{17}H_{25}N$	243	$\frac{14}{243} \times 100 = 5.76\%$

Maximum % N = LSD = 13.00%

Approach / Analogy

LSD has 3 nitrogen atoms (N_3), giving $3 \times 14 = 42$ g of N per mole. The others all have just 1 N (14 g per mole). Even though LSD has a larger molar mass, 3 nitrogen atoms compensate heavily. More N atoms = higher N mass fraction.

Common Mistake

Picking Phencyclidine ($C_{17}H_{25}N$) just because it has the *smallest* overall formula (thinking less other atoms means more N%). But LSD's 3 N atoms give it 42 g of nitrogen per mole vs. only 14 g for Phencyclidine. Three N atoms always beats one N atom unless the molar mass difference is extreme.

Answer

(3) LSD: $C_{20}H_{25}N_3O$

Q.7 Caffeine has a molecular weight of 194. It contains 28.9% by mass of nitrogen. Number of atoms of nitrogen in one molecule of caffeine is

Explanation

Step 1: Mass of N in one mole of caffeine.

$$\text{Mass of N} = \frac{28.9}{100} \times 194 = 56.066 \approx 56 \text{ g}$$

Step 2: Number of N atoms.

$$n_{\text{N}} = \frac{56}{14} = \mathbf{4}$$

Approach / Analogy

% composition → number of atoms: multiply % by M_r to get mass of element per mole, then divide by atomic mass to get number of atoms. $28.9\% \times 194/100 = 56$ g of N per mole. $56/14 = 4$ atoms. Caffeine (the molecule in your morning tea/coffee) has 4 nitrogen atoms.

Common Mistake

Dividing 28.9 by 14 directly (without first converting to actual mass using M_r). The % tells you the fraction, not the actual mass. First compute: mass of N per mole = $0.289 \times 194 = 56$ g, then divide by atomic mass of N (14).

Answer

(3) 4

Q.8 Number of Fe atoms in 100 g of Haemoglobin if it contains 0.33% Fe. (Atomic mass of Fe = 56)

Explanation

Step 1: Mass of Fe in 100 g of haemoglobin.

$$\text{Mass of Fe} = \frac{0.33}{100} \times 100 = 0.33 \text{ g}$$

Step 2: Moles of Fe.

$$n(\text{Fe}) = \frac{0.33}{56} = 5.893 \times 10^{-3} \text{ mol}$$

Step 3: Number of Fe atoms.

$$N = 5.893 \times 10^{-3} \times 6.022 \times 10^{23} = 3.548 \times 10^{21}$$

Closest option: $\mathbf{3.5 \times 10^{21}}$

Approach / Analogy

100 g sample makes Step 1 trivial: 0.33% of 100 g = exactly 0.33 g Fe. Then moles = 0.33/56. Then atoms = moles $\times N_A$. The answer 3.5×10^{21} is far less than one mole (6×10^{23}) because haemoglobin is a giant protein — each molecule has very few Fe atoms relative to its enormous mass.

Common Mistake

Confusing moles of Fe with number of atoms. $n(\text{Fe}) = 5.9 \times 10^{-3}$ mol is the number of moles, not atoms. Multiply by Avogadro's number to get atoms: $5.9 \times 10^{-3} \times 6.022 \times 10^{23} \approx 3.5 \times 10^{21}$ atoms.

Answer

(3) 3.5×10^{21}

Note

Option (3) in the printed paper says 3.5×10^{23} but calculation gives 3.5×10^{21}. Please verify with your answer key. The method above is correct.

Q.9 Insulin contains 3.4% sulphur. The minimum molecular weight of insulin is

Explanation

Key Concept: "Minimum" molecular weight assumes the molecule contains the *fewest possible* sulphur atoms, i.e., **1 atom of S**.

$$\%\ \text{S} = \frac{\text{mass of S in formula}}{M_r} \times 100$$

$$3.4 = \frac{1 \times 32}{M_r} \times 100$$

$$M_r = \frac{32 \times 100}{3.4} = \frac{3200}{3.4} = \mathbf{941.18 \approx 941.2}$$

Approach / Analogy

"Minimum molecular weight" is a standard type: assume 1 atom of the element per molecule (the bare minimum). If 1 S atom gives 3.4% of the total mass, and 1 S weighs 32 g/mol, then total molar mass = $32/0.034 = 941$. This is the smallest molecule consistent with the given %.

Common Mistake

Using atomic mass of S as 34 instead of 32. Sulphur's atomic mass is **32** g/mol, not 34. (H_2S = 34, but that's the molar mass of the molecule, not the atomic mass of S alone.) Using 34 gives 1000 instead of 941.

Answer

(1) 941.176

Q.10 A giant molecule contains 0.25% of a metal whose atomic weight is 59. Its molecule contains one atom of that metal. Its minimum molecular weight is

Explanation

One atom of metal per molecule, atomic weight = 59.

$$0.25 = \frac{59}{M_r} \times 100$$

$$M_r = \frac{59 \times 100}{0.25} = \frac{5900}{0.25} = \mathbf{23600}$$

Approach / Analogy

Same template as Q.9: 1 metal atom $\rightarrow$ mass = 59 g/mol. % = 0.25 means the metal is a tiny fraction of the giant molecule. Rearrange: $M_r = \frac{59}{0.0025} = 23600$. Very large M_r because the metal is only 0.25% — it's like finding a single gold coin in a huge chest.

Common Mistake

Writing $M_r = 59/0.25$ instead of $59/(0.25/100)$. The percentage must be divided by 100 to get the decimal fraction: 0.25% = 0.0025. So $M_r = 59/0.0025 = 23600$. Using 0.25 as the fraction (instead of 0.0025) gives $59/0.25 = 236$ — a factor of 100 error.

Answer

(2) 23600

Q.11 Percentage of Se in peroxidase anhydrous enzyme is 0.5% by weight (at. wt. = 78.4). The minimum molecular weight of peroxidase anhydrous enzyme is

Explanation

Minimum M_r assumes 1 Se atom per molecule.

$$0.5 = \frac{78.4}{M_r} \times 100$$

$$M_r = \frac{78.4 \times 100}{0.5} = \frac{7840}{0.5} = \mathbf{15680} = \mathbf{1.568 \times 10^4}$$

Approach / Analogy

Template: $M_r = \frac{\text{at. wt.} \times 100}{\%}$. Here: $M_r = 78.4 \times 100/0.5 = 78.4 \times 200 = 15680 = 1.568 \times 10^4$.

Common Mistake

Dividing 78.4 by 0.5 directly (without the $\times 100$). $78.4/0.5 = 156.8$ — this is 100 times smaller than the correct answer. Remember: % means "per 100," so $M_r = \text{mass}/(\%/100) = \text{mass} \times 100/\%$.

Answer

(1) 1.568×10^4

Q.12 A compound contains 0.5% of S. If the number of S atoms present per molecule is 2, then the molecular mass of the compound is

Explanation

Two S atoms per molecule ⇒ mass of S in formula = $2 \times 32 = 64$ g/mol.

$$0.5 = \frac{64}{M_r} \times 100$$

$$M_r = \frac{64 \times 100}{0.5} = \frac{6400}{0.5} = \mathbf{12800}$$

Approach / Analogy

Extension of Q.9–Q.11: instead of 1 atom, now 2 atoms of S. Total S mass in formula = $2 \times 32 = 64$. Apply same formula: $M_r = 64 \times 100/0.5 = 12800$. Compare with Q.11 (1 S atom at 0.5% would give $32 \times 100/0.5 = 6400$) — doubling the atoms doubles M_r.

Common Mistake

Using mass of 1 S atom (32) instead of 2 S atoms ($2 \times 32 = 64$). The question explicitly says 2 atoms of S. Missing this gives 6400 instead of 12800 — exactly half the correct answer.

Answer

(2) 12800

TYPE 5 : Miscellaneous

Q.13 In a sample of calcium phosphate $Ca_3(PO_4)_2$, 0.432 mole of phosphorous is present. What is the amount of calcium phosphate present in the sample if the sample is 100% pure? [Ca=40, P=31, O=16]

Explanation

Step 1: Moles of $Ca_3(PO_4)_2$ from moles of P.
Each formula unit of $Ca_3(PO_4)_2$ contains **2** phosphorus atoms.

$$n(Ca_3(PO_4)_2) = \frac{0.432}{2} = 0.216 \text{ mol}$$

Step 2: Molar mass of $Ca_3(PO_4)_2$.

$$M_r = 3(40) + 2(31) + 8(16) = 120 + 62 + 128 = 310 \text{ g/mol}$$

Step 3: Mass.

$$\text{Mass} = 0.216 \times 310 = \mathbf{66.96} \approx \mathbf{67} \text{ g}$$

Approach / Analogy

$Ca_3(PO_4)_2$ has the subscript 2 on PO_4 — so each formula unit has **2 P atoms**. Given 0.432 mol P, the compound = $0.432/2 = 0.216$ mol. Like knowing 0.432 wheels from a bicycle factory — each bike has 2 wheels, so that's 0.216 bikes.

Common Mistake

Using 0.432 mol as the moles of $Ca_3(PO_4)_2$ directly (1:1 ratio) instead of dividing by 2. $Ca_3(PO_4)_2$ has **two** phosphorus atoms per formula unit — always count the subscript on P.

Answer

(3) 67 g

Q.14 The crystalline salt $Na_2SO_4 \cdot xH_2O$ on heating loses 55.9% of its mass and becomes anhydrous. The formula of crystalline salt is

Explanation

The lost mass = mass of water.

Let the formula be $Na_2SO_4 \cdot xH_2O$.

M_r = $M_r(Na_2SO_4) + x \times 18 = 142 + 18x$

Mass of water lost = 55.9% of total:

$$\frac{18x}{142 + 18x} = \frac{55.9}{100} = 0.559$$

$$18x = 0.559(142 + 18x) = 79.378 + 10.062x$$

$$18x - 10.062x = 79.378 \implies 7.938x = 79.378 \implies x = \frac{79.378}{7.938} \approx 10$$

Formula: $Na_2SO_4 \cdot 10H_2O$

Approach / Analogy

Key identity: the % mass lost on heating = % water in the hydrated salt. Set up: water mass / total mass = 0.559. Solve for x. $M_r(\text{Na}_2\text{SO}_4) = 2(23) + 32 + 4(16) = 46 + 32 + 64 = 142$. Water per formula unit = $18x$. Solving gives $x = 10$.

Common Mistake

Using $M_r(\text{Na}_2\text{SO}_4) = 142$ but writing it as 140 or 144 due to arithmetic slips. Double-check: Na_2 = 46, S = 32, O_4 = 64. Total = 142. Also, "loses 55.9% mass" refers to the water leaving, not the salt remaining.

Answer

(4) $Na_2SO_4 \cdot 10H_2O$

Q.15 There are two oxides of sulphur. They contain 50% and 60% of oxygen respectively by weight. The weight of sulphur which combines with 1 g of oxygen is in the ratio of

Explanation

Oxide 1: 50% O. Then 50% S.
In 100 g: 50 g O + 50 g S.
Ratio: S per g of O $= \frac{50}{50} = 1$ g S per g O.

Oxide 2: 60% O. Then 40% S.
In 100 g: 60 g O + 40 g S.
Ratio: S per g of O $= \frac{40}{60} = \frac{2}{3}$ g S per g O.

Ratio: S in Oxide 1 : S in Oxide 2 = 1 : $\frac{2}{3}$ = **3** : **2**

This demonstrates the Law of Multiple Proportions — the ratio is a simple whole-number ratio.

Approach / Analogy

Fix the oxygen at 1 g and find how much S combines with it in each oxide. Oxide 1: 50% O means for every 50 g O there's 50 g S, so S per g O = 1. Oxide 2: 60% O means for every 60 g O there's 40 g S, so S per g O = 40/60 = 2/3. Ratio = 1 : 2/3 = 3:2.

Common Mistake

Comparing the sulphur percentages directly (50% vs 40%), getting ratio 50:40 = 5:4. But the question asks for S combining with a **fixed** amount of oxygen (1 g), not a fixed total mass. Normalise to equal oxygen before comparing S amounts.

Answer

(4) 3 : 2

Q.16 Chlorophyll, the green pigment in plants has the molecular formula $C_{55}H_{72}MgN_4O_5$. If 0.012 g of Mg is available to a plant for chlorophyll synthesis, how many grams of carbon will be required to completely use up the magnesium? [C = 12, Mg = 24]

Explanation

From the molecular formula: 1 Mg per formula unit and 55 C per formula unit.
Mole ratio: Mg : C = 1 : 55.

Step 1: Moles of Mg.

$$n(\text{Mg}) = \frac{0.012}{24} = 5 \times 10^{-4} \text{ mol}$$

Step 2: Moles of C needed.

$$n(\text{C}) = 55 \times 5 \times 10^{-4} = 0.0275 \text{ mol}$$

Step 3: Mass of C.

$$\text{Mass} = 0.0275 \times 12 = \mathbf{0.33} \text{ g}$$

Approach / Analogy

The molecular formula directly gives the atom ratio: 1 Mg : 55 C. So the mole ratio is also 1:55. Mg is the starting resource (given 0.012 g). Find moles of Mg, scale up by 55 for carbon moles, convert to mass. It's like a recipe: every 1 Mg atom needs 55 C atoms to make chlorophyll.

Common Mistake

Using the ratio 55:1 instead of 1:55 — i.e., finding moles of C first and dividing, instead of finding moles of Mg and multiplying by 55. Set up clearly: $n_C = 55 \times n_{Mg}$ (more C is needed per Mg). Also: the question gives Mg = 12 in the bracket, but this must be a typo in the original — atomic mass of Mg is **24** g/mol, not 12. Using 12 gives 0.001 mol Mg (double the correct value), giving 0.66 g carbon. If your answer key shows 0.66 g, the problem intends Mg = 12. Verify with source.

Answer

(1) 0.33 g

Note

The original paper states Mg = 12 (in the bracket) but the correct atomic mass of Mg is 24. Using Mg = 24: answer = 0.33 g (option 1). Using Mg = 12 as printed: $n(\text{Mg}) = 0.012/12 = 0.001$ mol $\rightarrow n(\text{C}) = 55 \times 0.001 = 0.055$ mol $\rightarrow$ mass = $0.055 \times 12 = 0.66$ g (option 2). Please verify with your answer key.

— End of DPP-4 Complete Solution Sheet —

Percentage Composition · Q.1 to Q.16 · All Questions Complete

"The difference between average and confident students is assignment completion."