Questions on Numbers of Particles

Avogadro's constant is 6.02×10^{23} mol^{-1}

1. 3.20 g of oxygen gas contains

   A. 0.200 mol O_2 molecules B. 0.100 mol O atoms
   C. 0.100 mol O_2 molecules D. 0.0500 mol O atoms

   A_r of oxygen is 16.00
   Oxygen gas is made up of O_2 molecules
   M_r of O_2 is 32.00 – mass of 1 mol O_2 is 32.00 g
   3.20 g of oxygen gas contains 3.20/32.00 = 0.100 mol O_2 molecules

   Alternatively:
   A_r of oxygen is 16.00
   3.20 g of oxygen contains 3.20/16.00 = 0.200 mol O *atoms*
   2 oxygen atoms per molecule, therefore the number of O_2 molecules = 0.200/2 = 0.100 mol

   It does not matter if the atoms are joined together or not – you can work out the number of moles of atoms just by dividing the total mass by the relative atomic mass

2. The number of H atoms in 0.20 mol $CH_4(g)$ is

   A. 1.2×10^{23} B. 4.8×10^{23} C. 3.0×10^{24} D. 1.2×10^{25}

   0.20 mol of CH_4 is $0.20 \times 6.02 \times 10^{23} = 1.2 \times 10^{23}$ CH_4 molecules
   4 H atoms per molecule, therefore the number of H atoms = $4 \times 1.2 \times 10^{23} = 4.8 \times 10^{23}$

3. What is the total number of ***atoms*** present in 0.0100 mol of propane, C_3H_8?

   A. 6.02×10^{21} B. 5.47×10^{20} C. 6.62×10^{22} D. 1.02×10^{23}

   Number of propane molecules = $0.0100 \times 6.02 \times 10^{23} = 6.02 \times 10^{21}$ molecules
   Number of atoms per molecule = 3+8 = 11
   Total number of atoms = $11 \times 6.02 \times 10^{21} = 6.62 \times 10^{22}$

4. How many oxygen atoms are in 2.48 g of $Na_2S_2O_3.5H_2O$?

   A. 6.02×10^{21} B. 1.81×10^{22} C. 4.82×10^{22} D. 3.01×10^{22}

   Because this is a multiple choice question there is no need to work out a molar mass using A_r values to 2 decimal places

   The $5H_2O$ must be included when working out the molar mass

   Molar mass of $Na_2S_2O_3.5H_2O$ = 22.99 x 2 + 32.07 x 2 + 16.00 x 3 + 5 x (2 x 1.01 + 16.00)
   = 248.22 g mol^{-1}
   Number of moles of $Na_2S_2O_3.5H_2O$ = 2.48/248.22 = 0.0100 mol

   Actually 0.00999…but this makes no difference for multiple choice

   Number of $Na_2S_2O_3.5H_2O$ units = $0.0100 \times 6.02 \times 10^{23} = 6.02 \times 10^{21}$
   Number of O atoms per $Na_2S_2O_3.5H_2O$ unit = 3 + 5 = 8

   Don't forget the O atoms from the $5H_2O$

   Total number of O atoms = $6.02 \times 10^{21} \times 8 = 4.82 \times 10^{22}$ atoms

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5. Which of the following contains the greatest number of oxygen atoms

A. 0.200 mol CO_2 B. 0.300 mol P_4O_6
C. 0.400 mol SO_3 D. 0.500 mol H_2O

0.200 mol CO_2 – 2 O atoms per molecule, therefore 2 x 0.200 = 0.400 mol O atoms
0.300 mol P_4O_6 – 6 O atoms per molecule, therefore 6 x 0.300 = 1.80 mol O atoms
0.400 mol SO_3 – 3 O atoms per molecule, therefore 3 x 0.400 = 1.20 mol O atoms
0.500 mol H_2O – 1 O atom per molecule, therefore 1 x 0.500 = 0.500 mol O atoms

6. Which of the following contains the greatest number of atoms

A. 1.0 g H_2(g) B. 4.4 g CO_2(g) C. 3.2 g SO_2(g) D. 5.0 g Ne(g)

Because this is a multiple choice question there is no need to work out molar masses using A_r values to 2 decimal places

1.0 g H_2 is 1.0/2 = 0.5 mol H_2
2 atoms per molecule, therefore total number of atoms = 2 x 0.5 = 1 mol
4.4 g CO_2 is 4.4/44 = 0.1 mol CO_2
3 atoms per molecule, therefore total number of atoms = 3 x 0.1 = 0.3 mol
3.2 g SO_2 is 3.2/64 = 0.05 mol SO_2
3 atoms per molecule, therefore total number of atoms = 3 x 0.05 = 0.15 mol
5.0 g Ne is 5.0/20 = 0.25 mol Ne
1 atom, therefore total number of atoms = 0.25 mol

7. 10.0 g of which of the following contains the greatest number of molecules

A. CO_2(g) B. NO(g) C. CH_4(g) D. N_2(g)

Because we have the same mass of each substance,
the one that contains the greatest number of molecules
will be the one with the lightest molecules

Compare – if you had 1 kg of tennis balls and 1 kg of ping pong balls, there would be more ping pong balls as each one is lighter.

CO_2 M_r=44 NO M_r=30 CH_4 M_r=16 N_2 M_r=28

8. Which of the following contains the same number of atoms as in 24.08 g CH_4?

A. 3.5 mol O_2 B. 0.5 mol O_3 C. 2.5 mol CO_2 D. 1.5 mol Ar

Number of moles in 24.08 g of CH_4 is 24.08/16.05 = 1.5 mol molecule
5 atoms per molecule, therefore total number of atoms = 5 x 1.5 = 7.5 mol

3.5 mol O_2 - 2 atoms per molecule, therefore total number of atoms = 2 x 3.5 = 7 mol
0.5 mol O_3 - 3 atoms per molecule, therefore total number of atoms = 2 x 0.5 = 1.5 mol
2.5 mol CO_2 - 3 atoms per molecule, therefore total number of atoms = 3 x 2.5 = 7.5 mol
1.5 mol Ar – 1 atom, therefore total number of atoms = 1 x 1.5 = 1.5 mol

Questions on Numbers of Particles

9. 100 g of which of the following contains the greatest number of *atoms*

A. $Ar(g)$ B. $Cl_2(g)$ C. $P_4(g)$ D. $S_8(g)$

Because we have the same mass of each substance, the one that contains the greatest number of atoms will be the one with the lightest atoms – it does not matter if the atoms are joined together into a molecule – 2 separate Cl atoms have the same total mass as the 2 Cl atoms in a Cl_2 molecule

	Ar	Cl	P	S
Relative atomic masses:	39.95	35.45	30.97	32.07

10. 1.0 dm^3 of which of the following contains the greatest number of *atoms*

A. $He(g)$ B. $CO_2(g)$ C. $H_2(g)$ D. $CH_4(g)$

The number of moles is proportional to the volume (Avogadro's Law), therefore 1.0 dm^3 of each contains the same number of *particles* (atoms for He, molecules for the others).

This means that the one with the greatest number of atoms will be the one with the largest number of atoms per particle – CH_4 has five atoms per molecule (particle).