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VCE Chemistry ½
Moles & Molar Mass [2.1]
Homework Solutions

Admin Info & Homework Outline:

Student Name	
Questions You Need Help For	
Compulsory Questions	Pg 2 - Pg 12
Supplementary Questions	Pg 13 - Pg 24

Section A: Compulsory Questions (50 Marks)

Sub-Section [2.1.1]: Apply Avogadro's Number to Mole Calculations using $n = N/N_a$

Question 1 (4 marks)

For the following, find the required value.

a. If a sample contained 2 moles of H_2 gas, how many particles of H_2 does it contain? (1 mark)

$2 \times 6.02 \times 10^{23} = 1.204 \times 10^{24}$ particles

b. Given that 9.03×10^{24} molecules of water existed, how many moles of water are in the sample? (1 mark)

$9.03 \times 10^{24} \ / \ 6.02 \times 10^{23} \ = \ 15$ moles

c. How many particles exist in 4.5 moles of CH_4? (1 mark)

$4.5 \times 6.02 \times 10^{23} = 2.709 \times 10^{24}$ particles

d. How many moles are in 1.89×10^{24} molecules of neon gas? (1 mark)

$1.89 \times 10^{24} \ / \ 6.02 \times 10^{23} \ = \ 3.14$ moles

Question 2 (3 marks)

Find the number of particles in the following.

a. In 3 moles of H_2, find the particles of hydrogen. (1 mark)

$3 \times 6.02 \times 10^{23} \times 2 = 3.612 \times 10^{24}$ particles of hydrogen

b. In 5 moles of NaCl, find the particles of sodium. (1 mark)

$5 \times 6.02 \times 10^{23} = 3.01 \times 10^{24}$ particles of sodium

c. In 3.06×10^{25} particles of nitrogen in nitrogen gas, find the moles of nitrogen gas. (1 mark)

$3.06 \times 10^{25} \ / \ 2 \ / \ 6.02 \times 10^{23} = 25.42$ moles

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Question 3 (6 marks)

Consider the compound of methane, CH_4.

a. If there are 3.01×10^{24} molecules of methane, how many moles of methane are present? (1 mark)

5 moles

b. How many carbon atoms are there in this amount of methane? (1 mark)

$3.01 \times 10^{24} \times 1 = 3.01 \times 10^{24}$ atoms

c. How many hydrogen atoms are there in this amount of methane? (1 mark)

$3.01 \times 10^{24} \times 4 = 1.204 \times 10^{25}$ atoms

d. Given that we have 3.311×10^{24} atoms of hydrogen in a sample of methane, calculate the moles of methane we have in total. (3 marks)

$3.311 \times 10^{24} / 4 = 8.2775 \times 10^{23}$ molecules of methane
$8.2775 \times 10^{23} / 6.02 \times 10^{23} = 1.375$ moles

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Sub-Section [2.1.2]: Apply Molar Mass to Mole Calculations using $n = m/M$

Question 4 (4 marks)

For the following substances, find their molar mass.

a. NH_3. (1 mark)

$14 + 3 = 17\ g\ mol^{-1}$

b. $ZnSO_4$. (1 mark)

$65.4 + 32.1 + (16 \times 4) = 161.5\ g\ mol^{-1}$

c. KI. (1 mark)

$39.1 + 126.9 = 166\ g\ mol^{-1}$

d. $AgNO_3$. (1 mark)

$107.9 + 14 + (16 \times 3) = 169.9\ g\ mol^{-1}$

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Question 5 (4 marks)

For the following samples, calculate the amount required.

a. Given that there is 2.4 g of H_2O, calculate the moles present. (1 mark)

$2.4/18 = 0.133$ moles

b. Given that there is 8.1 g of HCl, calculate the moles of hydrogen chloride. (1 mark)

$8.1/36.5 = 0.222$ moles

c. Given that there are 2.00 moles of LiF, calculate the mass present. (1 mark)

$2 \times 26 = 52\ g$

d. Given that there are 4.50 moles of $NaNO_3$, calculate the mass present. (1 mark)

$4.50 \times 85 = 382.5\ g$

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Question 6 (6 marks)

a. Explain what molar mass is. (2 marks)

Molar mass is the weight of 1 mole of a particular compound.

b. Given that a sample contains 5.90 moles and weighs 250.75 grams, what is its molar mass? (2 marks)

$250.75 / 5.90 = 42.5\ g\ mol^{-1}$

c. Based on this information, we also know that the compound contains 2 atoms, with one of them being lithium. What is the other atom? (2 marks)

Chlorine. ($42.5 - 7 = 35.5$ which is corresponding to chlorine.)

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Sub-Section [2.1.3]: Apply Unit Conversions to Calculation Questions

Question 7 (4 marks)

For the following, convert the current units to the units required.

a. 1.30 kg to mg. (1 mark)

$1.3 \times 10^6\ mg$

b. 2 days to minutes. (1 mark)

2880 minutes

c. 5000 micrograms to grams. (1 mark)

$5.0 \times 10^{-3}\ g$

d. 100 decimetres to millimetres. (1 mark)

10,000 mm

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Question 8 (4 marks)

Find the missing value for the following questions.

a. Given that a sample of $NaNO_3$ weighed 5.00 kg, what is the number of moles present? (1 mark)

$5000/85 = 58.82$ moles

b. Given that another sample of $AlCl_3$ weighed $1260\ mg$, what is the number of atoms of chlorine present? (3 marks)

$1260 / 1000 = 1.26\ g$
1.26 / 133.5 (molar mass) = 0.00944 moles
$0.00944 \times 6.02 \times 10^{23} \times 3 = 1.70 \times 10^{22}$ atoms of chlorine.

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Question 9 (5 marks)

Consider the compound, sodium sulphate.

a. What is its molar mass? (1 mark)

$Na_2SO_4 \rightarrow 46 + 32.1 + 64 = 142.1\ g\ mol^{-1}$

b. Given that, a sample contains 5.432×10^{-3} kilograms, what is the number of moles present? (2 marks)

$5.432 \times 10^{-3}\ kg = 5.432\ g$
$5.432 / 142.1 = 0.03822$ moles

c. Now, based on your answer, find the mass of sodium in the sample, expressed in micrograms. (2 marks)

$0.03822 \times 2 = 0.07645$ moles of sodium
$0.07645 \times 23 = 1.758$ grams = 1.758×10^6 micrograms

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Sub-Section: Final Boss

Question 10 (10 marks)

Consider an experiment where the aim is to experimentally determine Avogadro's number using a sample of potassium phosphate.

a. What is the molar mass of potassium phosphate? (1 mark)

$212.3\ g\ mol^{-1}$

b. Calculate the amount of moles of potassium phosphate present, given that the sample weighed out to be $39\ mg$. (3 marks)

$39\ mg$ is 3.90×10^{-2} grams
$0.039 / 212.3 = 1.84 \times 10^{4}$ moles of potassium phosphate

c. On the other hand, we know that the amount of potassium in the sample was equivalent to $1.966 \times 10^{-5}\ kg$. What is the amount of potassium atoms? For this question, you can use the known value of N_A. (2 marks)

$1.966 \times 10^{-5} \times 1000/39.1 = 0.0005028$ moles $\times\ 6.02 \times 10^{23} = 3.026 \times 10^{20}$ atoms

d. Given the information above, now find the experimental value of Avogadro's number. (2 marks)

3.026×10^{20} atoms $\times \frac{1}{3} = 1.0089 \times 10^{20}$ atoms of potassium phosphate
$1.0089 \times 10^{20} / 1.84 \times 10^{-4} = 5.48 \times 10^{23}\ mol^{-1}$

e. Briefly explain why Avogadro's number has the units it does. (2 marks)

It is because individual atoms/compounds do not have units in themselves and so as Avogadro's is saying "the number of particles per mole" it will be written as "mol^{-1}" (per mole).

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Section B: Supplementary Questions (61 Marks)

Sub-Section [2.1.1]: Apply Avogadro's Number to Mole Calculations using $n = N/N_a$

Question 11 (4 marks)

For the following questions, calculate the amount required.

a. The moles of magnesium atoms in 1.204×10^{24} particles. (1 mark)

2.00 moles

b. The particles of argon atoms in 19 moles. (1 mark)

1.144×10^{25} particles

c. The moles of francium atoms in 3.913×10^{24} particles. (1 mark)

6.5 moles

d. The particles of copper atoms in 9.654 moles. (1 mark)

5.820×10^{24} particles

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Question 12 (4 marks)

Find the number of particles in the following.

a. In 2 moles of O_2, find the particles of oxygen atoms. (1 mark)

$2 \times 6.02 \times 10^{23} \times 2 = 1.204 \times 10^{24}$ particles of O

b. In 4 moles of $CaCl_2$, find the particles of calcium ions. (1 mark)

$4 \times 6.02 \times 10^{23} = 2.408 \times 10^{24}$ particles of calcium

c. If we knew that a sample of CO_2 contained 1.20×10^{24} particles of oxygen, how many moles of CO_2 were there? (2 marks)

$1.20 \times 10^{24} / 2 / 6.02 \times 10^{23} = 0.997$ moles

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Question 13 (6 marks)

Consider the compound of ammonia, NH_3.

a. If there are 6.02×10^{24} molecules of ammonia, how many moles of ammonia are present? (1 mark)

10 moles

b. How many nitrogen atoms are there in this amount of ammonia? (1 mark)

$6.02 \times 10^{24} \times 1 = 6.02 \times 10^{24}$ atoms of N

c. How many hydrogen atoms are there in this amount of ammonia? (1 mark)

$6.02 \times 10^{24} \times 3 = 1.806 \times 10^{25}$ atoms of hydrogen

d. Given that we have 4.518×10^{24} atoms of hydrogen in a sample of ammonia, calculate the moles of ammonia we have in total. (3 marks)

$4.518 \times 10^{24} / 3 = 1.506 \times 10^{24}$ molecules of ammonia
$1.506 \times 10^{24} / 6.02 \times 10^{23} = 2.5$ moles of ammonia

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Question 14 (6 marks)

Consider the compound of $KMnO_4$, or commonly referred to as potassium permanganate.

a. Given that we have 6.41×10^{29} particles of oxygen, what number of particles of manganese and potassium do we have? (2 marks)

Manganese and potassium are both the same at 1.6025×10^{29} particles

b. Hence, what number of moles of potassium permanganate do we have? (1 mark)

$1.6025 \times 10^{29} / 6.02 \times 10^{23} = 2.66 \times 10^{5}$ moles

c. A student says that for 100 molecules of O_2 versus 100 molecules of Se_2, because Se is a much bigger molecule than O, their amount in moles will be different. Evaluate this statement. (3 marks)

This is false as moles and particles/molecules are related using $n = N/N_A$ and so we use moles as a way to group molecules together and count them more easily instead of using very large individual counting methods. Hence, as it's just used to count molecules/particles 100 molecules of both Se2 and O2 will be the same amount of moles. $\left(\frac{100}{6.02} \times 10^{23}\right) = 1.66 \times 10^{-22}$ moles

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Sub-Section [2.1.2]: Apply Molar Mass to Mole Calculations using $n = m/M$

Question 15 (4 marks)

For the following substances, find their molar mass.

a. CO_2. (1 mark)

$12 + 32 = 44\ g\ mol^{-1}$

b. KCl. (1 mark)

$39.1 + 35.5 = 74.6\ g\ mol^{-1}$

c. $CaCO_3$. (1 mark)

$40.1 + 12 + 48 = 100.1\ g\ mol^{-1}$

d. $C_6H_{12}O_6$. (1 mark)

$180\ g\ mol^{-1}$

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Question 16 (4 marks)

For the following samples, calculate the amount required.

a. Given that there is 5.0 g of CO_2, calculate the moles present. (1 mark)

$5/44 = 0.114$ moles

b. Given that there is 10.0 g of NaOH, calculate the moles of sodium hydroxide. (1 mark)

$10/40 = 0.25$ moles

c. Given that there are 3.00 moles of $MgCl_2$, calculate the mass present. (1 mark)

$3 \times 95 = 285\ g$

d. Given that there are 2.50 moles of KNO_3, calculate the mass present. (1 mark)

$2.50 \times 101 = 252.5\ g$

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Question 17 (5 marks)

a. Given that a sample contains 12.50 moles and weighs 778.75 moles, what is its molar mass? (2 marks)

$778.75 / 12.50 = 62.3\ g\ mol^{-1}$

b. Based on your understanding of molar mass, is it reasonable to assume that 10 g of $NaNO_3$ will be similar in amount to 10 g of $CsNO_3$? Explain. (3 marks)

No, because the molar mass of $NaNO_3$ is 85 $g\ mol^{-1}$ whereas $CsNO_3$ is 195 $g\ mol^{-1}$ Which means their respective mole amounts would be 0.117 vs. 0.0513, which means that there is double the amount of $NaNO_3$ compared to $CsNO_3$.

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Question 18 (7 marks)

Consider an unknown chemical X_2O. We know that there are 7.89×10^{25} atoms of oxygen in this sample.

a. What is the number of individual atoms in our sample? (2 marks)

$7.89 \times 10^{25} \times 3 = 2.367 \times 10^{26}$ atoms

b. Find the moles of X_2O. (2 marks)

$7.89 \times 10^{25} \,/\, 6.02 \times 10^{23} \;=\; 131.06$ moles

c. If the compound is 12345 grams, find its molar mass. (2 marks)

$12345 \,/\, 131.06 \;=\; 94.2\ g\ mol^{-1}$

d. What is X's identity? (1 mark)

$94.2 - 16 \;=\; 78.2 \,/2 \;= 39.1$ (POTASSIUM)

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Sub-Section [2.1.3]: Apply Unit Conversions to Calculation Questions

Question 19 (4 marks)

For the following, convert the current units to the units required.

a. Convert 5.50 kg to grams. (1 mark)

5500 grams

b. Convert 3 hours to seconds. (1 mark)

10800 seconds

c. Convert 7500 milligrams to kilograms. (1 mark)

$7.5 \times 10^{-3}\ kg$

d. Convert 25 micrometres to metres. (1 mark)

$2.5 \times 10^{-5}\ m$

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Question 20 (4 marks)

Find the missing value for the following scenarios.

a. Given that a sample of K_2SO_4 weighed 2.50 kg, what is the number of moles present? (1 mark)

$2.50 = 2500\ g, 2500 / 174 = 14.37$ moles

b. Given that another sample of $CaCl_2$ weighed 980 mg, what is the number of atoms of chlorine present? (3 marks)

$980\ mg = 0.98\ g$
$0.98 / 111 = 0.00883$ moles
$0.08833 \times 6.02 \times 10^{23} \times 2 = 1.06 \times 10^{22}$ atoms of chlorine

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Question 21 (5 marks)

Consider the compound of calcium bromide.

a. What is its molar mass? (1 mark)

$40.1 + 79.9 + 79.9 = 199.9$

b. Given that, a sample contains 9.7412×10^{-4} megagrams, what is the number of moles present? (2 marks)

$974.12\ g$
$974.12 / 199.9 = 4.87$ moles

c. Now, given that is the case, find the mass of bromine in the sample, expressed in milligrams. (2 marks)

$4.87 \text{ moles} \times 2 = 9.74$ moles of bromine
$9.74 \times 79.9 = 778.226$ grams of bromine $= 7.78 \times 10^5\ mg$

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Question 22 (8 marks)

Consider a molecule of $K_2Cr_2O_7$, commonly referred to as potassium dichromate.

a. What is the molar mass of this molecule? (1 mark)

$39.1 \times 2 + 2 \times 52 + 16 \times 7 \ = \ 294.2 \ g \ mol^{-1}$

b. What type of intramolecular bonding holds this molecule together? (1 mark)

Ionic bonding

c. If there was $20.3 \ mg$ of potassium dichromate present, how many moles of it are present? (1 mark)

$20.3 \times 10^{-3} \ / \ 294.2 \ = \ 6.90 \times 10^{-5}$ moles

d. From your previous answer, calculate the number of molecules of potassium dichromate present. (2 marks)

$6.90 \times 10^{-5} \times 6.02 \times 10^{23} = 4.15 \times 10^{19}$ molecules

e. Now, state how many kilograms of oxygen was present in the sample. (3 marks)

$4.15 \times 10^{19} \times 7 = 2.908 \times 10^{20}$ atoms of oxygen / $6.02 \times 10^{23} \ = \ 6.9 \times 10^{-5}$ moles of oxygen $\times \ 16 \ = \ 1.104 \times 10^{-3}$ grams of oxygen $= 1.10 \times 10^{-6} \ kg$

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