BioMedical Admissions Test (BMAT)

Section 2: Chemistry

Questions by Topic

C4 - Quantitative Chemistry

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(Mark Scheme and explanations at the end)

1 What is the mass (in kg) of 50 mol of sulphuric acid?
[A_r: H = 1, O = 16, S = 32]

A 4.1kg
B 1.96kg
C 4.85kg
D 4.9kg

2 The unbalanced chemical equation for a displacement reaction is shown below:
$CaO + C \rightarrow CaC_2 + CO$

How many grams of CaC_2 is produced if 36g of carbon is used in the reaction?
[A_r: C = 12, O = 16, Ca = 40]

A 64g
B 92g
C 32g
D 96g

3 The chemical equation for the combustion of butane is shown below:
$2C_4H_{10} + 13O_2 \rightarrow 8\ CO_2 + 10H_2O$

How much butane was burnt if 360g of water was produced by the reaction?
[A_r: H = 1, C = 12, O = 16]

A 290g
B 232g
C 384g
D 1160g

4 In one mole of ethanol the percentage mass made from hydrogen is 13.1%. There are a total of 6 hydrogen atoms in 1 molecule of ethanol.

What is the mass of one mol of ethanol?

[A_r: H = 1, C = 12, O = 16]

A 32.1g
B 36.1g
C 42.6g
D 46.2g

5 An explosion of TNT created a number of different products.
The equation for this is:

e $C_6H_2CH_3(NO_2)_3 \rightarrow$ ***f*** CO **+** ***g*** C + ***h*** N_2 + ***i*** H_2O

What is the value of ***f***?

A 4
B 5
C 6
D 7

6 A compound is made of carbon, hydrogen and oxygen only. It contains 58.82% carbon and 31.38% oxygen and has an M_r of 102.

What is the molecular formula of the compound?
[A_r: H = 1, C = 12, O = 16]

A $C_4H_{10}O_3$
B $C_5H_{10}O_2$
C $C_4H_{10}O_3$
D $C_6H_{14}O$

7 5.6g of potassium hydroxide is dissolved in a volume of 500cm^3.

What concentration in mol dm^{-3} is formed?
[A_r: H = 1, O = 16, K = 39]

A 0.2
B 5
C 0.01
D 20

8 There is 10cm^3 of a 0.25mol dm^{-3} solution of sodium hydroxide.

What is the amount of solute present in this solution?

A 2.5 mol
B 2.5 x 10^{-3} mol
C 2.5 x 10^{-4} mol
D 5 x 10^{-3} mol

9 An unknown compound's mass is made of 84.9% carbon and the remainder from hydrogen.

What is the molecular formula of the compound?

A C_6H_8
B C_8H_8
C $C_{12}H_{26}$
D $C_{23}H_{26}$

10 Below is the equation for the complete combustion of ethane.
$\boldsymbol{w}\ C_2H_6 + \boldsymbol{x}\ O_2 \rightarrow \boldsymbol{y}\ CO_2 + \boldsymbol{z}\ H_2O$

When all the values are whole numbers, what is the value of ***z***?

A 3
B 4
C 5
D 6

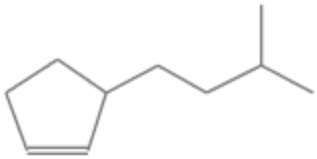
11 There are three main isotopes of magnesium; ^{24}Mg, ^{25}Mg and ^{26}Mg. Respectively, their abundances are 78.6%, 10.1% and 11.3%.

Calculate the relative atomic mass of magnesium.

A 23
B 23.9
C 24.3
D 25.5
E 26

12 The skeletal formula of cyclopentane (C_5H_{10}) is:

Use this information, and the Periodic Table, to determine the relative atomic mass of the compound shown below.



A 24
B 185
C 98
D 138

13 17.85g of methane (CH_4) undergoes complete combustion at room temperature and pressure (RTP).

Approximately what volume of carbon dioxide is produced by this reaction? Assume that 1 mole of a gas at standard temperature and pressure has a volume of 22.4 dm^3

(Molecular weights: C = 12, H = 1)

A 25000cm^3
B 25cm^3
C 21cm^3
D 27000cm^3

14 1.93g of Fe^{2+} ions are reacted with aqueous sodium hydroxide solution (NaOH). Assume that iron hydroxide, $Fe(OH)_2$, is produced in a 1:1 molar ratio with Fe^{2+} ions.

What is the mass of iron hydroxide produced, and what observation would you expect to make?

(Molecular weights: Fe = 56, O = 16, H = 1, Na = 23)

A 3.25g and a green precipitate
B 360g and a blue precipitate
C 3.10g and a green precipitate
D 2.8g and a cloudy white precipitate
E 3.25g and an orange-brown precipitate
F 3.10g and an orange-brown precipitate

15 3.97g of butane (C_4H_{10}) undergoes complete combustion in air to produce 5.28g of water.

By balancing this equation, determine the percentage yield of water in this reaction.

(Molecular weights: C = 12, H = 1, O = 16)

A 82.1%
B 57.3%
C 85.7%
D 98.3%

16 A metal, A, reacts violently when exposed to water and, when exposed to a flame, burns yellow. Another element, B is in Group 7 of the Periodic Table, exists as a diatomic, shiny purple solid at RTP (room temperature and pressure).

5g of A reacts with an excess of B at RTP. What mass of the product, AB, is formed?

(Molecular weights: Li = 7, Na, = 23, K = 39, Rb = 85, F = 19, Cl = 35, Br = 80, I = 127)

A 20.11g
B 12.59g
C 32.55g
D 9.28g
E 17.11g

17 3.82g of copper was mixed with an excess of nitric acid, HNO_3. Two of the products of this reaction were nitrogen oxide gas (NO) and water (H_2O). There was one other product produced. The reaction occurred at RTP (room temperature and pressure)

Using the balanced equation for this reaction, determine the expected volume of nitrogen oxide gas produced.

(Molecular weights: Cu = 64, H = 1, NO_3^{2-} = 164, N = 14, O = 16)

A 8.70g
B 1.20g
C 9.37g
D 7.75g
E 9.38g

18 1.58g of $MgCl_2$ is added to an excess of sodium hydroxide, NaOH. What is the total number of moles formed in this reaction, and the total mass of product formed?

(Molecular masses: Mg = 24, Cl = 35, Na = 23, O = 16, H = 1)

A 2.78 mol and 1.98 g
B 0.08 mol and 1.78 g
C 0.05 mol and 2.96 g
D 0.05 mol and 1.98 g
E 2.78 mol and 2.96 g

19 A student reacts 3.7 g of sodium with an excess of water. 2.1g of NaOH were produced. Calculate the percentage yield of this reaction, and suggest the sign of the energy change (ΔH)

(Molecular weights: Mg = 24, Na = 23, O = 16, H = 1)

1 32.6% yield, ΔH negative
2 32.6% yield, ΔH positive
3 45.8% yield, ΔH positive
4 45.8% yield, ΔH negative
5 92.5% yield, ΔH negative
5 92.5% yield, ΔH positive

20 A new element, vibranium, has been discovered and exists naturally as 94.80% vibranium-123, 3.50% vibranium-124 and 1.70% vibranium-128. Calculate the relative atomic mass of vibranium to 2 decimal places.

A 127.30
B 124.89
C 124.01
D 123.12
E 123.20

21 A compound T with the empirical formula CH and the relative formula mass 78 g/mol is decomposed to evolve a pungent gas X that is often used as a fuel. The other compounds produced are solid carbon and acetylene, C_2H_2.

If 3.30g of compound T is used in this reaction, calculate the volume of gas X evolved.

(1 mole of gas is equivalent to 24 dm^3)

A 3.56 dm^3
B 1.01 dm^3
C 1.82 dm^3
D 2.88 dm^3
E 3.12 dm^3

22 75g of hexane is cracked to form 17g of propene and 58g of propane. Using this information, calculate the percentage yield of propene formed in this reaction.

A 100.0%
B 85.3%
C 46.4%
D 92.3%
E 56.7%

23 Ammonia is reacted with methane to form hydrogen cyanide, HCN.

Calculate the volume of hydrogen cyanide produced from 1.35g of ammonia.

(1 mole of gas is equivalent to 24 dm^3)

A 2.87 dm^3
B 2.10 dm^3
C 8.76 dm^3
D 1.91 dm^3
E 0.89 dm^3

Answers and Explanations

1 **The answer is D**

The formula for sulphuric acid is H_2SO_4 with an M_r of 98
We can substitute the values into this equation:
Mass in g = molar mass x number of moles
Mass in g = 98 x 50 = 4900 = 4.9kg

2 **The answer is A**

First balance the equation: $CaO + 3C \rightarrow CaC_2 + CO$
Using the A_r we can work out that M_r of C is 12 and CaC_2 is 64
We can substitute the values into this equation to calculate moles of C:

$$\text{Number of moles} = \frac{\text{mass in g}}{\text{molar mass}} = \frac{36}{12} = 3$$

As there are 3 moles of C for every mole of CaC_2 (a ratio of 3:1), there would be 1 moles of CaC_2 produced.
Mass of CaC_2 in g = molar mass x number of moles = 64 x 1 = 64g

3 **The answer is B**

Using the A_r we can work out that M_r of C_4H_{10} is 58 and H_2O is 18
We can substitute the values into this equation to calculate moles of H_2O:

$$\text{Number of moles} = \frac{\text{mass in g}}{\text{molar mass}} = \frac{360}{18} = 20$$

As there are 10 moles of H_20 for every 2 moles of C_4H_{10} (a ratio of 5:1), there would be 4 moles of C_4H_{10} used.
Mass of butane in g = molar mass x number of moles = 58 x 4 = 232g

4 **The answer is D**

This question is slightly different as it does not give the exact mass of the compound. We have been told that there are 6 H atoms in one ethanol molecule.

H has an A_r of 1 so the 6 H atoms have a total relative mass of 6, which is 13.1% of the relative mass of the ethanol molecule.

13.1% is roughly $\frac{13}{100}$

Therefore:

$$\frac{\text{Relative mass of H atoms}}{\text{Relative mass of ethanol}} = \frac{13}{100}$$

now knowing that the relative mass of H is 6 this is:

$$\frac{6}{\text{Relative mass of ethanol}} = \frac{13}{100}$$ which can be rearranged to:

$$\text{Relative mass of ethanol} = \frac{100 \times 6}{13} = \frac{600}{13} = \sim 46.1$$ which is closest to answer D

> ***Exam tip*** **-** Do not be put off by difficult percentages or fractions - it is sometimes better to use an estimated fraction to find the answer that is closest, rather than wasting time working out the exact number

5 **The answer is B**

First balance the nitrogen on both sides, so you will have 2 molecules of $C_6H_2CH_3(NO_2)_3$ and 3 of N_2. Then balance the hydrogen, to give 2 molecules of water. You can then balance the oxygen and finally the carbon atoms in order to find out the molecules of CO needed.

1. Balance the nitrogens - this means that there will be 2 molecules of $C_6H_2CH_3(NO_2)_3$ and 3 of N_2.
2. Next, balance the hydrogen, to give 5 molecules of water.
3. This leaves 7 oxygen to form carbon monoxide.
4. Therefore the answer is D

6 **The answer is B**

The compound is 58.82% is C, 31.38% is O which means the H is 9.8% is H.
The M_r is 102.

If we round all these to easier numbers we can calculate that:

C: 60% of 100 = 60	O: 32% of 100 = 32	H: 10% of 100 = 10
The A_r of C is 12 so this means 5 atoms of carbon	The A_r of O is 16 so this means 2 atoms of oxygen	The A_r of H is 1 so this means 10 atoms of hydrogen

7 **The answer is A**

M_r of KOH = 39 + 16 + 1 = 56

$$\text{No. moles} = \frac{\text{mass}}{M_r} = \frac{5.6}{56} = 0.1 \text{ mol}$$

$$\text{Concentration} = \frac{\text{amount of solute (mol)}}{\text{volume of solution (dm}^3\text{)}} = \frac{0.1 \times 1000}{500} = 0.2$$

8 **The answer is B**

Mol of NaOH = volume (dm^3) x concentration

$$= \frac{10}{1000} \times 0.25 = 2.5 \times 10^{-3} \text{ mol}$$

9 **The answer is C**

A C_6H_8 - C: 6x12 = 72 H: 8x1 = 8 M_r = 80 72/80 = 90%
B C_6H_6 - C: 6x12 = 72 H: 6x1 = 6 M_r = 78 72/78 = ~92%
C $C_{12}H_{26}$ - C: 12x12 = 144 H: 26x1 = 26 M_r = 170 144/170 = ~85%
D C_8H_{28} - C: 8x12= 96 H: 28x1 = 28 M_r = 124 96/124 = ~76%

Exam tip **-** Sometimes it is easier to look at the answers given to work backwards to find the answer

10 **The answer is D**

The correctly balanced equation is:

$$\mathbf{2}C_2H_6 + \mathbf{7}O_2 \rightarrow \mathbf{4}CO_2 + \mathbf{6}H_2O$$

11 **The answer is C**

$$Relative\ atomic\ mass = \frac{(mass\ of\ isotope\ 1 \times its\ relative\ abundance) + (mass\ of\ isotope\ 2 \times its\ relative\ abundance)}{sum\ of\ the\ relative\ abundances}$$

The abundances of each isotope is given in %. You can assume that you have 100 typical atoms, which means the relative abundance of each isotope becomes the %:

^{24}Mg	78.6
^{25}Mg	10.1
^{26}Mg	11.3

The sum of the relative abundance = $78.6 + 10.1 + 11.3 = 100$

$$RAM = \frac{(24 \times 78.6) + (25 \times 10.1) + (26 \times 11.3)}{100} = 24.327$$

This can be easier to calculate if we approximate some values.

$24 \times 78.6 \Rightarrow 24 \times 80 = 1,920$

$25 \times 10.1 \Rightarrow 25 \times 10 = 250$

$26 \times 11.3 \Rightarrow 26 \times 11 = 286$

$$RAM = \frac{1920 + 250 + 286}{100} \Rightarrow \frac{2456}{100} = 24.56$$

Looking at the answer options, the option closest to this is 24.3. And so **C is the correct answer.**

12 **The answer is D** - 138.

The relative atomic mass of cyclopentane is 70. As the structure shown contains a double bond (cyclopent**ene**) we remove two hydrogen atoms from this to get 68. Counting the atoms in the rest of the structure, we get 70. Adding 70 to 68 results in a final atomic mass of 138.

13 **The answer is A**

The molecular weight of methane is 16 g/mol. This means that there are 1.116 moles of methane present. Using moles=mass/mr.
Writing the balanced equation for this reaction demonstrates that carbon dioxide is produced in a 1:1 ratio with methane, so simply multiply 1.116mol x 22.4dm^3/mol to get an answer of 24.998dm^3 of carbon dioxide produced.
This is equivalent to 24998cm^3, or approximately 25000cm^3 of gas.

14 **The answer is C**

1.93/56 = 0.034 moles of Fe^{2+} present, and also 0.034 moles of $Fe(OH)_2$.
Atomic mass of $Fe(OH)_2$ is 56 + ((16+1) x 2) = 90.
0.034 * 90 = 3.10g.
$Fe(OH)_2$ is formed as a **green** precipitate in this reaction.

15 **The answer is C**

The balanced equation for this reaction is C_4H_{10} + 6 ½ O_2 -> 4CO_2 + 5H_2O.
Butane's atomic mass is 58, so 3.97g / 58 = 0.068 moles of butane.
This is multiplied by 5 (1:5 molar ratio) to get 0.342 moles of water.
0.342 moles * 18 (atomic mass of water) = 6.16g of water expected.
With everything converted into mass, we use the yield formula:
% yield =actual yield / expected yield x 100:
5.28g/6.16g x 100 = **85.7% yield.**

16 **The answer is C**

A is sodium (Na) and B is iodine (I). The balanced equation for this reaction is

$$2Na + I_2 \rightarrow 2NaI.$$

5g/23 = 0.217mol

Na = 0.217 mol = NaI
0.217 * 150 (atomic mass of NaI)
= **32.55g NaI.**

17 **The answer is B**

The other product is copper nitrate, $Cu(NO_3)_2$, and the balanced equation is

$3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$.

It can be seen that the molar ratio between copper and nitrogen oxide, NO, is 1 : ⅔ .

Using this information:

- 3.82g Cu / 64 = 0.060 mol Cu
- 0.060 x ⅔ = 0.040 mol NO
- 0.040 x 30 = **1.20g NO**

18 **The answer is C**

The balanced equation is $MgCl_2 + 2NaOH \rightleftharpoons Mg(OH)_2 + 2NaCl$.

Atomic mass of $MgCl_2$ = 95 g/mol.

Atomic mass of $Mg(OH)_2$ = 58 g/mol.

Atomic mass of NaCl = 58 g/mol.

- 1.58g / 95 g/mol = 0.017 mol $MgCl_2$
- 1:1 molar ratio with $Mg(OH)_2$ so = 0.017 mol $Mg(OH)_2$ formed (x 58 = 0.986g)
- 1:2 molar ratio with NaCl so = 0.034 mol NaCl formed. (x 58 = 1.972g)
- Total moles = 0.017 + 0.034 = 0.051 mol
- Total mass = 0.986 + 1.972 = 2.958 g

19 **The answer is A**

The balanced reaction is $2Na + 2H_2O \rightarrow 2NaOH + H_2$.

3.7g / 23 = 0.161 mol Na.

1:1 molar ratio with NaOH so 0.161 mol NaOH.

Atomic mass of NaOH is 40 g/mol, so 0.161 x 40 = 6.44g.

2.1g / 6.44g X 100= 32.6% yield.

This is an explosive, strongly exothermic reaction, so ΔH will be extremely negative.

20 **The answer is D**

To calculate the relative atomic mass of vibranium, the calculation is:

(94.8 x 123) + (3.5 x 124) + (1.7 x 128) /100

((11660.4 + 434 + 217.6) /100) = **123.12.**

21 **The answer is B**

The compound with the relative formula mass 78g/mol and empirical formula CH is benzene, C_6H_6.
This can be calculated either by deduction, or by calculation: 78/13 = 6, which when multiplied by the empirical formula gives C_6H_6.
The gas evolved, by description, must be methane, CH_4.
Therefore the balanced equation for the reaction described is:

$$C_6H_6 \rightarrow CH_4 + C_2H_2 + 3C.$$

Using the normal method: 3.30/78 = 0.042mol C_6H_6.
1:1 ratio so 0.042 mol CH_4.
0.042 x 24 = **1.008dm^3 CH_4.**

22 **The answer is C**

The relative atomic mass of hexane is 86 g/mol, and propene is 42 g/mol.
The balanced equation is $C_6H_{14} \rightarrow C_3H_6 + C_3H_8$.
75/86 = 0.872 mol hexane = **0.872 mol propene.**
0.872 mol x 42 = **36.62g.**
To calculate percentage yield: (17.00g/36.62g) x 100 = **46.4% yield.**

23 **The answer is D**

The balanced equation for this reaction is $NH_3 + CH_4 \rightarrow HCN + 3H_2$.
The relative formula mass of ammonia is 17 g/mol, and HCN is 27 g/mol.
1.35g / 17 = 0.079mol NH_3 = **0.079 mol HCN.**
0.079mol x 24 mol/dm^3 = **1.905 dm^3.**