04 Chemical Formulae, Equations, the Mole and Gases

Set B Competition Practice

Name	Time 45 minutes	Total 22 marks	Score ____ / 22

Marks by notes section For the marker: total each row. A score below the target means that section of the notes needs revising.

Notes section	Questions	Marks	Target	Score
1 Chemical Equations	1	1	1	
2 Relative Masses	2, 3	2	2	
3 The Mole	4, 5, 6, 7	4	3	
4 Empirical and Molecular Formulae	8, 9, 10	3	2	
5 Reacting Masses	11	1	1	
6 Solutions	12	1	1	
7 Gas Volumes	13	1	1	
8 The Ideal Gas Equation	14, 15, 16, 17, 18, 19, 20, 21, 22	9	6	

A Competition questions

22 MARKS

1 The first six ionisation energies of an element, M, in kJ mol^{-1} are 660, 1267, 2218, 3313, 7863 and 9500. M forms its only chloride by heating M with chlorine. What is the equation for the formation of the chloride of M?

A $2M + Cl_2 \rightarrow 2MCl$

B $M + Cl_2 \rightarrow MCl_2$

C $M + 2Cl_2 \rightarrow MCl_4$

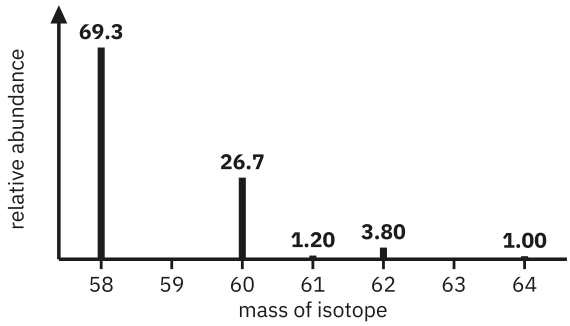
D $M + 3Cl_2 \rightarrow MCl_6$

/1

Answer ☐ [1]

Source: SJChO Mock 3 P1 Q3

2 The relative abundances of all the isotopes present in a sample of nickel are shown.



What is the relative atomic mass of nickel calculated from these data?

A 58.8 **B** 59.8 **C** 59.9 **D** 61.0

Answer ☐ [1]

/1

SJChO Mock 3 P1 Q2

3 The relative atomic mass of antimony, which consists of the isotopes ^{121}Sb and ^{123}Sb, is 121.8. What is the percentage of ^{123}Sb in the isotopic mixture?

A 40% **B** 45% **C** 50% **D** 60%

Answer ☐ [1]

/1

2019 RVHS J1 Common Test P1 Q2

4 If there are n molecules in 10 g of methane, CH_4, how many molecules are in 55 g of carbon dioxide?

A 4n **B** 2n **C** n **D** 0.5n

Answer ☐ [1]

/1

2023 SJChO P1 Q39

5 Which of the following statements about 20.3 g of $Co_2(SO_4)_3$ is false? [Molar mass = 406 g mol^{-1}]

A This amount is equivalent to 1.2 dm^3 of hydrogen at 293 K and 1 atm.

B It contains 47.3% of oxygen by mass.

C It contains 0.15 mol of SO_4^{2-} ions.

D It contains 3.01×10^{22} ions.

Answer ☐ [1]

/1

2019 RVHS J1 Common Test P1 Q1

6 Which of the following quantities is equal to the Avogadro constant?

A The number of atoms in 24 dm^3 of oxygen under room temperature and pressure.

B The number of molecules in 1 dm^3 of chlorine at 273 K and 1.5 atm.

C The number of ions in 68.05 g of $CaSO_4$.

D The number of carbon atoms in 22.7 dm^3 of ethane gas, C_2H_6, under standard temperature and pressure.

Answer ☐ [1]

/1

2021 EJC J2 Prelim P1 Q8

7 Which substances contain the same number of atoms?

1 1.20 mol of NH_3
2 1.445×10^{24} molecules of O_2
3 36.0 g of $C_6H_{12}O_6$
4 57.6 dm^3 of Cl_2 at room temperature and pressure

A 1 and 2 only **B** 1 and 3 only **C** 2 and 4 only **D** 1, 2, 3 and 4

Answer [1]

/1

2024 VS O Prelim P1 Q10

8 Complete combustion of a sample of a hydrocarbon, Y, gave 0.66 g of carbon dioxide and 0.36 g of water. What is the empirical formula of Y?

A C_3H_4 **B** C_3H_5 **C** C_3H_8 **D** C_6H_8

Answer [1]

/1

2020 YIJC J2 Prelim P1 Q20

9 A 2.0 g sample containing 0.0130 mol of an organoboron compound, with the formula $C_xH_yBO_z$, was burnt in an excess of oxygen. 4.58 g of CO_2 and 1.76 g of H_2O were produced. What is the molecular formula of the organoboron compound?

A CH_2BO_2 **B** $C_8H_7BO_2$ **C** $C_8H_{15}BO_2$ **D** $C_9H_{15}BO$

Answer [1]

/1

2021 SAJC J2 Prelim P1 Q3

10 The empirical formula of an oxide of element X is X_2O_5. 106.5 g of X_2O_5 contains 60 g of oxygen. What is the identity of X?

A $^{31}_{15}P$ **B** $^{40}_{20}Ca$ **C** $^{70}_{31}Ga$ **D** $^{175}_{71}Lu$

Answer [1]

/1

2025 CHIJ O Prelim P1 Q12

11 Sodium hydrogencarbonate, $NaHCO_3$, can be prepared from sodium sulfide, Na_2S, by the following reactions.

$Na_2S(s) + CaCO_3(s) \rightarrow CaS(s) + Na_2CO_3(s)$
$Na_2CO_3(s) + H_2O(l) + CO_2(g) \rightarrow 2NaHCO_3(s)$

Assuming that the percentage yield in each step is identical, 20.5 kg of sodium hydrogencarbonate (M_r = 84.0) was formed from 50 kg of sodium sulfide (M_r = 78.1). What is the percentage yield of each step?

A 13.8% **B** 43.7% **C** 61.8% **D** 70.7%

Answer [1]

/1

2022 VJC J1 Promo P1 Q7

12 What is the volume of distilled water that must be added to 50 cm^3 of 0.280 mol dm^{-3} $KMnO_4$ to dilute it to 0.160 mol dm^{-3}?

A 11.5 cm^3 **B** 37.5 cm^3 **C** 38.5 cm^3 **D** 87.5 cm^3

/1

Answer [1]

2022 AMSR Topical Revision Q10

13 Amedeo Avogadro discovered that equal volumes of gases at the same temperature and pressure contain the same number of molecules. Two closed containers, A and B, hold gases at the same temperature and pressure. The mass of gas A is equal to the mass of gas B, but gas A has a higher density than gas B. Which of the following statements is true?

A The molar mass of A < the molar mass of B

B The number of atoms in A < the number of atoms in B

C The number of molecules in A < the number of molecules in B

D The volume of A > the volume of B

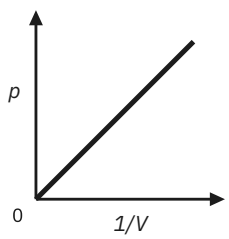
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Answer [1]

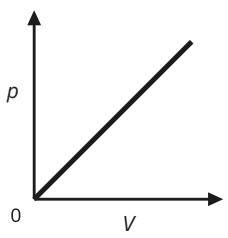
2023 SJChO P1 Q42

14 Which graph is a correct representation of Boyle's law?

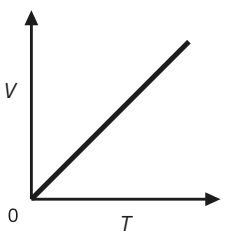
A



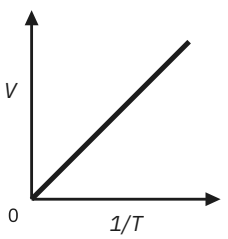
B



C



D



A graph A **B** graph B **C** graph C **D** graph D

/1

Answer [1]

SJChO Mock 3 P1 Q27

15 0.0353 g of a sample of volatile organic compound was completely vaporised at 50 kPa and 300 K. The vapour occupied a volume of 40 cm^3. On complete combustion in excess oxygen, 80 cm^3 of carbon dioxide and 80 cm^3 of water vapour were formed. All gaseous volumes were measured under identical conditions. What would be the molecular formula of the compound? (R = 8.31 J K^{-1} mol^{-1})

A C_2H_2O **B** C_2H_4O **C** C_2H_6O **D** C_3H_8

/1

Answer [1]

2022 NJC J2 Prelim P1 Q4

16 In an experiment, 0.100 g of a volatile liquid Q formed 0.0250 dm^3 of vapour at 100 °C and 1 bar. What is the relative molecular mass of Q?

A $\frac{0.100 \times 373}{0.0250 \times 22.7}$

B $\frac{0.0250 \times 273 \times 22.7}{0.100 \times 373}$

C $\frac{0.100 \times 273 \times 22.7}{0.0250 \times 373}$

D $\frac{0.100 \times 373 \times 22.7}{0.0250 \times 273}$

/1

Answer [1]

2022 YIJC J2 Prelim P1 Q6

17 Deuterium, ^{2}H, is an isotope of hydrogen. In an experiment, 18.0 g of gas A at 40 °C is found to occupy the same volume as 0.6 g of deuterium gas, $^{2}H_2$, at 20 °C. The pressure of gas A is twice that of the deuterium gas. What is the relative molecular mass of gas A?

A 32.0 **B** 60.0 **C** 64.1 **D** 120

Answer [1]

/1

2024 VJC J2 Prelim P1 Q5

18 A 20 dm^3 vessel contains 0.25 mol of ammonia gas and a 30 dm^3 vessel contains 0.42 mol of hydrogen chloride gas. When the two vessels were connected at 500 K, the following reaction occurs: $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$. What is the resultant pressure, in Pa, in the combined vessel? ($R = 8.31\ J\ K^{-1}\ mol^{-1}$)

A 14 127 **B** 20 775 **C** 34 902 **D** 55 677

Answer [1]

/1

2023 TJC J2 Prelim P1 Q8

19 An equimolar mixture of H_2 and O_2 was placed in a sealed, rigid container at room temperature. The total pressure inside the container is P Pa. The mixture was sparked, and H_2 and O_2 reacted until H_2 was completely consumed. What is the partial pressure, in Pa, of O_2 in the container after the reaction at room temperature?

A 2P **B** P **C** 0.5P **D** 0.25P

Answer [1]

/1

2020 RI J1 Promo P1-P3 Q6

20 A gaseous sample containing x dm^3 of gaseous methanol, CH_3OH, was burnt in 4x dm^3 of oxygen to produce carbon dioxide and water vapour. The total pressure in the system after combustion was P. Which statements are correct?

1 Methanol reacts with oxygen in a 2 : 3 mole ratio.
2 The partial pressure of carbon dioxide in the system is 0.18P.
3 Assuming these gases behave ideally, they occupy an insignificant volume.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 1 only

Answer [1]

/1

2021 DHS J2 Prelim P1 Q5

21 $F_2(g)$ and Xe(g) are added to a container of fixed volume. The initial partial pressure of $F_2(g)$ is 7.0 atm and that of Xe(g) is 1.6 atm. When all of the Xe(g) has reacted with $F_2(g)$ to form a solid compound, C, the pressure of unreacted $F_2(g)$ is 3.8 atm. The temperature remained constant throughout. What is the formula of the solid compound C?

A XeF **B** XeF_2 **C** XeF_3 **D** XeF_4

Answer [1]

/1

2022 Gaseous State Topical Revision Q12

22 Analysis of a mixture of sulfur-containing gases shows that hydrogen sulfide, H_2S, and carbon disulfide, CS_2, are present in a 2 : 1 mole ratio. The mixture is burned in excess oxygen, forming SO_2, CO_2 and H_2O. Which row describes the SO_2 : CO_2 mole ratio after complete combustion, and the relative deviation from ideal behaviour of the gases CO_2 and CS_2?

	SO_2 : CO_2 mole ratio	relative deviation
A	3 : 1	CS_2 deviates more than CO_2
B	4 : 1	CS_2 deviates more than CO_2
C	3 : 1	CO_2 deviates more than CS_2
D	4 : 1	CO_2 deviates more than CS_2

A row A **B** row B **C** row C **D** row D

/1

Answer [1]

2024 DHS J2 Prelim P1 Q3

10 The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0		**Key** atomic number atomic symbol name relative atomic mass									5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.2	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –