MCQ 50 marks

1. **C.** 3.614×10^{23}

Explanation: $n = \frac{8.8}{44} = 0.2$ mol

Number of molecules $= 0.2 \times 6.023 \times 10^{23} = 1.2046 \times 10^{23}$

3 atoms per molecule $\Rightarrow$ total $= 3.614 \times 10^{23}$

2. **A. 0.0495 mol**

Explanation: Moles of air $= \frac{PV}{RT} = \frac{98 \times 6.2}{8.314 \times 310} = 0.2357$ mol

$n_{O_2} = 0.21 \times 0.2357 = 0.0495$ mol

3. **B. 19.16 L**

Explanation: $n = \frac{22}{44} = 0.5$ mol

$V = \frac{nRT}{P} = \frac{0.5 \times 0.0821 \times 350}{0.75} = 19.16$ L

4. **D.** 1.44×10^6 K

Explanation: $P = \frac{\varrho RT}{M} \Rightarrow T = \frac{PM}{\varrho R}$

$M = 1.6 \times 10^{-3}$ kgmol^{-1}

$T = \frac{9.0 \times 10^9 \times 1.6 \times 10^{-3}}{1.2 \times 8.314} = 1.44 \times 10^6$ K

5. **B. 87°C**

Explanation: $T_2 = T_1 \times \frac{P_2 V_2}{P_1 V_1}$

$T_2 = 300 \times \frac{6.0 \times 0.10}{2.0 \times 0.25} = 360$ K

$= 87°C$

6. **D. 1.6 g**

Explanation: At the same T, P and V the number of moles is equal (Avogadro's law)

$n_{SO_2} = \frac{6.4}{64} = 0.1$ mol $= n_{CH_4}$

$m_{CH_4} = 0.1 \times 16 = 1.6$ g

7. **C.** 1.2×10^{-2} m^3

Explanation: $\frac{V_2}{V_1} = \frac{T_2}{T_1} = \frac{200}{400}$

$V_2 = 2.4 \times 10^{-2} \times 0.5 = 1.2 \times 10^{-2}$ m^3

8. **B. 0.6408 atm**

Explanation: $n = \frac{1.2046 \times 10^{22}}{6.023 \times 10^{23}} = 0.02$ mol

$P = \frac{nRT}{V} = \frac{0.02 \times 0.0821 \times 320}{0.82} = 0.6408$ atm

9. **D. −42.6°C**

Explanation: At constant volume $P \propto T$

$T_2 = 288 \times 0.8 = 230.4$ K

$= 230.4 - 273 = -42.6°C$

10. **A. −1 and 135°**

Explanation: $PV = k \Rightarrow \log V = -\log P + \log k$

Slope $m = -1$

$\tan\theta = -1 \Rightarrow \theta = 135°$

11. **D.** 44.3 gmol^{-1}

Explanation: Volume of the vessel $= \frac{335.40 - 85.40}{1.00} = 250$ mL $= 0.250$ L

Mass of gas $= 85.85 - 85.40 = 0.45$ g

$n = \frac{1 \times 0.250}{0.0821 \times 300} = 0.01015$ mol

$M = \frac{0.45}{0.01015} = 44.3$ gmol^{-1}

12. **A. −273.13°C**

Explanation: $V_\theta = V_0\left(1 + \frac{\theta}{|t_0|}\right)$

$\frac{2.5858}{2.0} = 1 + \frac{80}{|t_0|}$

$\frac{80}{|t_0|} = 0.2929$

$|t_0| = 273.13 \Rightarrow t_0 = -273.13°C$

13. **C.** Cl_2

Explanation: $r \propto \frac{1}{\sqrt{M}}$

$M_{Cl_2} = 71$ is the highest $\Rightarrow$ its rate is the lowest

14. **B. 36**

Explanation: $d_x = d_{SO_2}\left(\frac{r_{SO_2}}{r_x}\right)^2 = 32 \times \left(\frac{3}{4}\right)^2 = 18$

$M = 2 \times 18 = 36$

15. **D. 31.5**

Explanation: $r_{N_2} = \frac{12}{40} = 0.3$ m^3/s; $r_X = \frac{18}{90} = 0.2$ m^3/s

$d_X = 14 \times \left(\frac{0.3}{0.2}\right)^2 = 14 \times 2.25 = 31.5$

16. **B. NO and C_2H_4**

Explanation: Equal molar mass $\Rightarrow$ equal rate of diffusion

NO = 30, $C_2H_4 = 28$ — unequal

17. **A. 48 min**

Explanation: $n_{SO_2} = \frac{6.4}{64} = 0.1$ mol; $n_{CH_4} = \frac{6.4}{16} = 0.4$ mol

Molar effusion rate $\propto \frac{1}{\sqrt{M}} \Rightarrow t \propto n\sqrt{M}$

$\frac{t_{CH_4}}{t_{SO_2}} = \frac{0.4}{0.1} \times \sqrt{\frac{16}{64}} = 4 \times \frac{1}{2} = 2$

$t_{CH_4} = 2 \times 24 = 48$ min

18. **C. 1 : 9**

Explanation: $\frac{r_A}{r_B} = \frac{n_A}{n_B}\sqrt{\frac{M_B}{M_A}}$

$\frac{n_A}{n_B} = \frac{2/M_A}{1/M_B} = 2\frac{M_B}{M_A}$

Let $x = \frac{M_B}{M_A}$; $54 = 2x \cdot \sqrt{x} = 2x^{3/2}$

$x^{3/2} = 27 \Rightarrow x = 9$

$M_A : M_B = 1 : 9$

19. **B. 21%**

Explanation: $x_{O_2} = \frac{p_{O_2}}{P} = \frac{21.21}{101} = 0.21$

Volume percentage = mole percentage = 21%

20. **C. P**

Explanation: $P_{mix} = \frac{PV + P(2V)}{3V} = P$

21. **D. 1.2 L**

Explanation: $\frac{V_{CH_4}}{V_{He}} = \sqrt{\frac{4}{16}} = \frac{1}{2}$

$V_{CH_4} = 2.4 \times \frac{1}{2} = 1.2\,L$

22. **D. 36.58 kPa**

Explanation: At 25°C: $p_{CH_4} = \frac{90 \times 0.30}{0.80} = 33.75\,kPa$

At 50°C: $p'_{CH_4} = 33.75 \times \frac{323}{298} = 36.58\,kPa$

23. **C. 0.45 atm**

Explanation: $x_{N_2} = \frac{3}{2+3+5} = 0.3$

$p_{N_2} = 0.3 \times 1.5 = 0.45\,atm$

24. **A. 1.21 atm**

Explanation: $P = \frac{\sum P_i V_i}{V} = \frac{1.2 \times 150 + 0.9 \times 250 + 2.0 \times 100}{500}$

$= \frac{180 + 225 + 200}{500} = 1.21\,atm$

25. **D. 25**

Explanation: Volume of a balloon = $\frac{4}{3}\pi(0.40)^3 = 0.2681\,m^3$

Usable pressure = 1500 − 101.325 = 1398.675 kPa

Usable gas volume at STP = $\frac{1398.675 \times 0.5}{101.325} \times \frac{273}{280} = 6.7294\,m^3$

Number of balloons = $\frac{6.7294}{0.2681} = 25.10 \approx 25$

26. **B.** $\sqrt{\frac{2RT}{M}}$

Explanation: $C_{mp} = \sqrt{\frac{2RT}{M}}$

27. **D.** $624.3\,ms^{-1}$

Explanation: $C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3 \times 8.314 \times 250}{0.016}}$

$C = 624.3\,ms^{-1}$

28. **C.** $460.4\,ms^{-1}$

Explanation: $C_{mp} : \bar{c} : C_{rms} = 1 : 1.128 : 1.225$

$\bar{c} = 500 \times \frac{1.128}{1.225} = 460.4\,ms^{-1}$

29. **D. 2**

Explanation: $\frac{T_1}{M_1} = \frac{T_2}{M_2} \Rightarrow M = 32 \times \frac{350}{400} = 28$

$14n = 28 \Rightarrow n = 2\ (C_2H_4)$

30. **B. 4 : 11**

Explanation: $E_k = \frac{3}{2}nRT$; at the same T, $E_k \propto n$

$\frac{E_{CO_2}}{E_{CH_4}} = \frac{1/44}{1/16} = \frac{16}{44} = \frac{4}{11}$

31. **A. 402°C**

Explanation: $C \propto \sqrt{T} \Rightarrow \frac{T_2}{T_1} = (1.5)^2 = 2.25$

$T_2 = 300 \times 2.25 = 675\,K$

$= 402°C$

32. **B. 87.8°C**

Explanation: $T = \frac{MC^2}{3R} = \frac{0.004 \times (1500)^2}{3 \times 8.314}$

$T = 360.8\,K$

$= 87.8°C$

33. **D. 3 : 4**

Explanation: $P = \frac{1}{3}\varrho C^2$

$\frac{P_A}{P_B} = \frac{\varrho_A}{\varrho_B} \times \left(\frac{C_A}{C_B}\right)^2$

$= 3 \times \left(\frac{1}{2}\right)^2 = \frac{3}{4}$

34. **A.** $6.624 \times 10^{-21}\,J$

Explanation: The average kinetic energy per molecule depends only on temperature

$\bar{E} = \frac{3}{2}kT = 1.5 \times 1.38 \times 10^{-23} \times 320 = 6.624 \times 10^{-21}\,J$

35. **B. Correction for the actual volume of the molecules**

Explanation: b: the volume correction due to the intrinsic volume of the molecules

36. **A. 1.97 atm**

Explanation: Ideal: $P = \frac{nRT}{V} = \frac{1.2 \times 0.0821 \times 350}{1.5} = 22.99\,atm$

vdW: $\frac{nRT}{V - nb} = \frac{34.482}{1.5 - 0.04452} = 23.69\,atm$

$\frac{an^2}{V^2} = \frac{4.17 \times 1.44}{2.25} = 2.67\,atm$

$P_{vdW} = 21.02\,atm$

Difference = 22.99 − 21.02 = 1.97 atm

37. **D.** H_2

Explanation: The intermolecular attraction (a) of H_2 and He is very small
So the volume correction (b) dominates ⇒ $Z > 1$

38. **C.** $38.24\ \text{gmol}^{-1}$
Explanation: $PV = ZnRT \Rightarrow n = \frac{PV}{ZRT}$
$n = \frac{180 \times 8.0}{0.92 \times 8.314 \times 300} = 0.6275\ \text{mol}$
$M = \frac{24.0}{0.6275} = 38.24\ \text{gmol}^{-1}$

39. **A.** $Z = 1 + \frac{Pb}{RT}$
Explanation: At high pressure V is small but P is large; P is much greater than $\frac{a}{V^2}$
$P(V - b) = RT \Rightarrow PV = RT + Pb$
$Z = \frac{PV}{RT} = 1 + \frac{Pb}{RT}$

40. **A. 2**
Explanation: Acidity = number of replaceable OH^- ions per molecule
$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$

41. **B.** HCl
Explanation: An Arrhenius acid gives H^+ ions in aqueous solution
$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

42. **A. Lewis theory**
Explanation: The octet of Al in $AlCl_3$ is incomplete
It accepts an electron pair ⇒ Lewis acid

43. **C.** $NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$
Explanation: The Arrhenius theory applies only to aqueous solutions
In the gas phase HCl is the proton donor and NH_3 is the proton acceptor — explainable by the Brønsted-Lowry theory

44. **C.** H_3PO_3
Explanation: Only H atoms bonded to O are replaceable
H_3PO_3: two P–OH and one P–H ⇒ dibasic

45. **B.** O_3
Explanation: O_3 forms in the air through chemical reactions ⇒ it is a secondary pollutant

46. **C. 5.6**
Explanation: Dissolved atmospheric CO_2 makes the pH of normal rain ≈ 5.6
Rain with pH < 5.6 is acid rain

47. **A.** SO_2
Explanation: FGD = Flue Gas Desulfurization
SO_2 is absorbed by limestone/lime:
$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$

48. **C. 0.05 ppm**
Explanation: ppm = mg/L
$\frac{0.0125\ \text{mg}}{0.250\ \text{L}} = 0.05\ \text{mg/L} = 0.05\ \text{ppm}$

49. **D. 0.03125 M**
Explanation: Mass of O_2 in 500 mL = $6.4 \times 0.5 = 3.2\ \text{mg}$
$n_{O_2} = \frac{3.2 \times 10^{-3}}{32} = 1.0 \times 10^{-4}\ \text{mol}$
$O_2 \equiv 4Na_2S_2O_3 \Rightarrow n = 4.0 \times 10^{-4}\ \text{mol}$
$M = \frac{4.0 \times 10^{-4}}{12.8 \times 10^{-3}} = 0.03125\ \text{M}$

50. **B. Chlorination**
Explanation: Chlorination is a disinfection method; it does not remove dissolved solids