1. **A** – energy/CO_2: CH_4 = 890 kJ; ethanol ≈ 685 kJ; propane ≈ 740 kJ; octane ≈ 684 kJ – highest for methane.

2. **D** – The balanced equation releases –789 kJ per mole of hydrazine, and 3 mol × (–789 kJ mol^{-1}) = -2.37×10^3 kJ.

3. **C** – NH_3 accepts H^+ to form NH_4^+, so is the base.

4. **C** – The electrophile has attacked the carbon directly opposite (para) to the methyl group, consistent with the ortho-/para-directing nature of an electron-donating CH_3 substituent.

5. **B** – Ba^{2+} and PO_4^{3-} combine in a 3 : 2 ratio to balance charge, giving $Ba_3(PO_4)_2$.

6. **A**: Melting point correlates with lattice energy, which increases with higher charge density; the smaller Li^+ and F^- give the greatest charge density and strongest attraction.

7. **B** – mobile electrons allow charge flow, giving electrical conductivity.

8. **B** – Metals already have partially-filled bands; hotter lattices scatter carriers. Silicon is a semiconductor with a small band gap, so heating generates additional electron–hole pairs and higher conductivity.

9. **A** – delocalised electrons in graphite allow conduction; diamond has none and is extremely hard.

10. **B** – One repeat unit contains 5 C atoms (2 in the backbone, 3 in CH_3 groups), 9 H atoms (from three CH_3 groups) and 1 Cl atom ⇒ C_5H_9Cl.

11. **C** – Spontaneity when ΔG = 0: T = ΔH/ΔS = 40 000 J ÷ 120 J K^{-1} ≈ 333 K (closest to 330 K).

12. **A** – E°cell = 0.77 – 0.15 = +0.62 V; n = 2 e^-, so ΔG° = –nFE° ≈ $-2 \times 9.65 \times 10^4 \times 0.62$ = -1.2×10^5 J.

13. **B** – Freezing reduces molecular disorder by converting a liquid into an ordered solid lattice.

14. **B** – The fractionating column packed with beads allows multiple vaporisation–condensation cycles, ensuring better separation of components with close boiling points.

15. **A** – sulfur (Z = 16) fills orbitals to $3p^4$.

16. **B** – In B the first electron removed is a 2p electron; 2p orbitals are higher in energy and less penetrating than 2s, so the electron is held less tightly despite the higher nuclear charge.

17. **A –** Q = 500 g × 4.18 J g^{-1} °C^{-1} × 10.9 °C = 2.28×10^4 J = 22.8 kJ

Fuel mass burned = 20.24 g − 19.48 g = 0.76 g

$\Delta H_{(comb)}$ per gram = 22.8 / 0.76 ≈ 3.0 × 10^1 kJ g^{-1} (exothermic)

18. **D** – low temperature and high pressure enhance intermolecular forces and particle volume effects.

19. **A** – Diagram A shows products at a higher energy level than reactants (endothermic) and an activation barrier approximately twice the height of the net enthalpy change.

20. **C** - 0.12 g Mg ÷ 24.3 g mol^{-1} = 4.94 × 10^{-3} mol.
 $Mg + Cl_2 \rightarrow MgCl_2$ (1 : 1).
 Mass $MgCl_2$ = 4.94 × 10^{-3} mol × 95.3 g mol^{-1} ≈ 0.47 g.

21. **C** - n = 2.00 g / 100.1 g mol^{-1} ≈ 0.020 mol; V = nRT/P ≈ 0.020 × 8.31 × 298 / 1.00 × 10^5 = 4.95 × 10^{-4} m^3 = 4.95 × 10^2 cm^3.

22. **D** – higher T favours the endothermic reverse reaction, shifting left and lowering Kc.

23. **D** – Increasing pressure favours the side with fewer gas molecules (NH_3), so % NH_3 should rise with pressure. Lower temperature favours the exothermic forward reaction, so the 400 °C curve must lie above the 500 °C curve. Only diagram D shows both trends.

24. **C** – Higher pressure favours the side with fewer gas moles (1 mol vs 2 mol); exothermicity is secondary when only pressure changes.

25. **A**. The H-O-N angle is determined by a bent arrangement around the oxygen (≈104°), while the nitrogen is trigonal-planar, giving an O-N-O angle of ≈120°.

26. **B** – The Arrhenius form $\ln k = -E_a/RT + \ln A$ is linear when ln k (here $k \propto 1/t$) is plotted against $1/T$, giving gradient $-E_a/R$.

27. **A** – Rate-determining step involves A_2 + B; because $[A_2] \propto [A]^2$ from the fast pre-equilibrium, the overall rate law is rate = $k[A]^2[B]$, matching the experimental orders (second order in A, first in B).

28. **C** – For a strong monoprotic acid, $[H^+]$ = 1.0 × 10^{-3} M; pH = $-\log[H^+]$ = 3.

29. **B** – Henderson–Hasselbalch: pH = pK_a + log([salt]/[acid]) = 4.76 + log(0.20/0.10) = 4.76 + 0.30 = 5.06.

30. **B** – Magnesium, with the more negative E°, is oxidised (anode); the SHE is reduced (cathode). Hence electrons move Mg → Pt and E°cell = 0 – (–2.37) = +2.37 V.

31. **B** – A very broad O–H stretch overlapping 2500 – 3300 cm^{-1} combined with a C=O stretch around 1700 cm^{-1} is characteristic of a carboxylic acid.

32. **C** – Raising the temperature spreads the energy distribution: more particles have higher energies, the peak moves right and lowers, but particle number (area) stays the same.

33. **A** – Liquid M contains four carbon atoms and a terminal -CHO group, so the correct name is butanal.

34. **B** –The terminal –CHO group is an aldehyde.

35. **B** – Electrophilic addition follows Markovnikov's rule, giving 2-bromopropane.

36. **A** – First-order kinetics dependent only on the halide concentration indicates an SN1 mechanism with a rate-determining ionisation step forming a stable tertiary carbocation.

37. **B** – The concentration falls from about 0.083 mol dm^{-3} to 0.060 mol dm^{-3} in 10 s ($\Delta[H_2O_2]$ ≈ 0.023 mol dm^{-3}). Rate = 0.023 / 10 ≈ 2.3×10^{-3} mol dm^{-3} s^{-1}.

38. **C** – Water has two bonding pairs and two lone pairs, giving a bent geometry with ≈ 104.5° H–O–H bond angle.

39. **B** – 0.250 mol × 6.02 × 10^{23} mol^{-1} = 1.51 × 10^{23} molecules.

40. **C** - Applying Hess's law:
$2\ \Delta_a$□$H(Ag)$ + 1462 + 249.2 – 141.1 + 798 – 2969 = –31 → $2\ \Delta_a$□$H(Ag)$ ≈ 570 kJ mol^{-1} → Δ_a□$H(Ag)$ ≈ 285 kJ mol^{-1}.