S6 Chemistry Practice Paper | Hess law, equilibrium constant, electrolysis, titration and buffer, polymerisation and rate order

Chemistry | Time allowed：60 minutes | Total marks：100 marks | 24

：CH4(g) −74.8 kJ mol⁻¹、CO2(g) −393.5 kJ mol⁻¹、H2O(l) −285.8 kJ mol⁻¹。C(s) + O2(g) → CO2(g) ΔH −393.5 kJ mol⁻¹、2H2(g) + O2(g) → 2H2O(l) ΔH −571.6 kJ mol⁻¹、CH4(g) + 2O2(g) → CO2(g) + 2H2O(l) ΔH −890.3 kJ mol⁻¹。

1. (a) Find the standard enthalpy of complete combustion of methane from the formation enthalpies.

Answers： Answer: dH = [-393.5 + 2(-285.8)] - (-74.8) = -890.3 kJ mol-1.

2. (b) Find the energy released by burning 8.0 g of methane completely, with M(CH4) = 16.0 g mol-1, to one decimal place.

Answers： Answer: moles = 8.0 / 16.0 = 0.500 mol; energy = 0.500 x 890.3 = 445.2 kJ.

3. (c) Use Hess law with the three combustion enthalpies to find the standard enthalpy of formation of methane and compare it with the given value.

Answers： Answer: dHf = (-393.5) + (-571.6) - (-890.3) = 0.0 kJ mol-1, the same as the given -74.8 kJ mol-1, so the difference is 0.0 kJ mol-1.

4. (d) Given the atomisation enthalpy of C(s) as +715 kJ mol-1 and the bond enthalpy of H2(g) as +436 kJ mol-1, find the C-H bond enthalpy to one decimal place.

Answers： Answer: 715 + 2(436) - 4x = -74.8, so 4x = 1661.8 and x = 415.4 kJ mol-1, about 415 kJ mol-1.

700 K，0.20 mol H2、0.20 mol I2 1.60 mol HI 2.0 dm³，H2(g) + I2(g) ⇌ 2HI(g)。

5. (a) Find the equilibrium concentration of each species and Kc.

Answers： Answer: [H2] = [I2] = 0.20 / 2.0 = 0.10 mol dm-3 and [HI] = 1.60 / 2.0 = 0.80 mol dm-3; Kc = 0.80 squared / (0.10 x 0.10) = 64.

6. (b) A further 1.00 mol of HI is added at constant temperature. Find the reaction quotient Qc at that instant and state the direction of the shift.

Answers： Answer: [HI] = 2.60 / 2.0 = 1.30 mol dm-3; Qc = 1.30 squared / (0.10 x 0.10) = 169, which exceeds Kc = 64, so the equilibrium shifts left towards the reactants.

7. (c) Another experiment has 0.10 mol of H2, 0.30 mol of I2 and 0.60 mol of HI in 2.0 dm3. Find Qc and state the direction of the shift.

Answers： Answer: the concentrations are 0.05, 0.15 and 0.30 mol dm-3; Qc = 0.30 squared / (0.05 x 0.15) = 12, which is below Kc = 64, so the equilibrium shifts right towards the products.

8. (d) In a 1.0 dm3 vessel the starting amounts are 0.50 mol of H2 and 0.50 mol of I2. Find the equilibrium concentration of HI and the percentage conversion of H2.

Answers : Answer: let x mol react; 4x squared / (0.50 - x) squared = 64 gives 2x / (0.50 - x) = 8 and x = 0.40; [HI] = 0.80 mol dm-3, [H2] = 0.10 mol dm-3 and conversion = 0.40 / 0.50 x 100% = 80%.

2.0 A (II) 30 minutes （96500 C mol⁻¹，Ar(Cu) = 63.5、Ar(Ag) = 107.9）。

9. (a) Find the charge passed and the number of moles of electrons, to four decimal places.

Answers : Answer: Q = It = 2.0 x 1800 = 3600 C; n(e-) = 3600 / 96500 = 0.0373 mol.

10. (b) Find the mass of copper deposited at the cathode, to two decimal places.

Answers : Answer: n(Cu) = 0.0373 / 2 = 0.0187 mol; mass = 0.0187 x 63.5 = 1.18 g.

11. (c) If 5.0 A is passed through silver nitrate solution for 1.5 hours instead, find the mass of silver deposited to one decimal place.

Answers : Answer: Q = 5.0 x 5400 = 27000 C; n(e-) = 27000 / 96500 = 0.2798 mol; n(Ag) is the same; mass = 0.2798 x 107.9 = 30.2 g.

12. (d) Electrolysis of dilute sulphuric acid gives 240 cm3 of hydrogen at a molar volume of 24.0 dm3 mol-1. Find the volume of oxygen, the charge passed and the time needed at 0.50 A, in minutes to one decimal place.

Answers : Answer: n(H2) = 240 / 24000 = 0.0100 mol; n(O2) = 0.0050 mol, volume = 120 cm3; n(e-) = 0.02 mol so Q = 0.02 x 96500 = 1930 C; t = 1930 / 0.50 = 3860 s, that is 64.3 minutes.

0.100 M 25.0 cm³ 0.100 M （$K_a = 1.8 \times 10^{-5}$）。

13. (a) Find the volume of sodium hydroxide needed to reach the equivalence point.

Answers : Answer: n(CH3COOH) = 0.100 x 0.0250 = 2.50 x 10-3 mol; the same moles of NaOH are needed, so the volume = 2.50 x 10-3 / 0.100 = 25.0 cm3.

14. (b) Find the pH of the acid before any alkali is added, to two decimal places.

Answers : Answer: [H+] = square root of (1.8 x 10-5 x 0.100) = 1.34e-03 M; pH = 2.87.

15. (c) Find the pH after 20.0 cm3 of sodium hydroxide has been added, to two decimal places.

Answers : Answer: acid left = 2.50 x 10-3 - 2.00 x 10-3 = 5.00 x 10-4 mol and salt formed = 2.00 x 10-3 mol; [H+] = 1.8 x 10-5 x (5.00e-04 / 2.00e-03) = 4.50e-06 M; pH = 5.35.

16. (d) Find the pH after 12.5 cm3 of sodium hydroxide has been added and explain the buffer action at that point.

Answers : Answer: the acid and the salt are present in equal amounts of 1.25 x 10-3 mol, so [H+] = Ka and pH = pKa = 4.74. The solution holds both unreacted ethanoic acid and sodium ethanoate, which neutralise small additions of strong acid or alkali, so the pH changes very little.

280000 （C2H4，28.0 g mol⁻¹）。-6,6 ，C12H22N2O2。PET C10H8O4（Ar：C = 12.01、H = 1.008、N = 14.01、O = 16.00）。

17. (a) Find the degree of polymerisation of the polyethylene.

Answers： Answer: degree of polymerisation = 280000 / 28.0 = 10000.

18. (b) Find the molar mass of the nylon-6,6 repeat unit, to two decimal places.

Answers： Answer: 12(12.01) + 22(1.008) + 2(14.01) + 2(16.00) = 226.32 g mol-1.

19. (c) If the nylon has an average molecular mass of 22632, find its degree of polymerisation and state how condensation polymerisation differs from addition polymerisation.

Answers： Answer: degree of polymerisation = 22632 / 226.32 = 100. In condensation polymerisation each bond formed releases a small molecule such as water and the monomers must each carry two functional groups, whereas addition polymerisation joins monomers that contain carbon to carbon double bonds and releases nothing.

20. (d) Find the molar mass of the PET repeat unit and the average molecular mass when the degree of polymerisation is 150, as a whole number.

Answers： Answer: 10(12.01) + 8(1.008) + 4(16.00) = 192.16 g mol-1; average molecular mass = 192.16 x 150 = 28825 g mol-1.

A + B → C ：[A] = 0.10 M、[B] = 0.10 M，2.0×10^{-3} mol dm⁻³ s⁻¹；[A] = 0.20 M、[B] = 0.10 M，8.0×10^{-3}；[A] = 0.10 M、[B] = 0.20 M，4.0×10^{-3}。

21. (a) Find the order with respect to A and with respect to B and write the rate equation.

Answers： Answer: doubling [A] from experiment 1 to 2 raises the rate four times, so the order in A is 2; doubling [B] from experiment 1 to 3 doubles the rate, so the order in B is 1. The rate equation is rate = k[A] squared [B] and the overall order is 3.

22. (b) Find the rate constant k and its unit.

Answers： Answer: k = 2.0 x 10-3 / (0.10 squared x 0.10) = 2.0 dm6 mol-2 s-1.

23. (c) Find the initial rate when [A] = 0.30 M and [B] = 0.15 M.

Answers： Answer: rate = 2.0 x 0.30 squared x 0.15 = 0.027 mol dm-3 s-1.

24. (d) A second reaction is first order with k = 0.0693 min-1. Find its half-life and the time for the concentration to fall from 0.80 M to 0.10 M.

Answers： Answer: t half = ln2 / 0.0693 = 10.0 min; the fall 0.80 to 0.40 to 0.20 to 0.10 covers 3 half-lives, so the time = 3 x 10.0 = 30.0 min.