# CHEM 111 2018 EXAM MARK SCHEME

# Section A (1 – 5)

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| **1.** | (a) | M1: Cu2O |
|  | (b) | M2: KMnO4 |
|  | (c) | M3: Ca(NO3)2 |
|  | (d) | M4: Al2S3  |
|  | (e) | M5: NaClO3[5] |
| **2.** | (a) | M1: n (BaO2) = 5 / 169.3 = 0.0295 and n (H2SO4) = 0.05 x 2 = 0.1M2: n (H2SO4) > n (BaO2) so H2SO4 is in excessM3: n (H2O2) = 0.0295 so C (H2O2) = 0.0295/0.05 = 0.59 moldm-3 |
|  | (b) | M4: mr of H2O2 = 34 and total mr = 34 + 233.4 = 267.4M5: % ae = 34/267.4 x 100 = 12.7% [5] |
| **3.** | (a) | M1: 23.3/40.1 and 18.6/32.1 and 55.7/16 and 2.3/1 = 0.58:0.58:3.24:2.3M2: = 1:1:6:4 so ef = CaSO6H4M3 = CaSO4.2H2O |
|  | (b) | M4: 5 x 136.2/172.2 M5: = 3.95 g [5] |
| **4.** | M1: n (K) = 2.5/39.1 = 0.064M2: n (KOH) = 0.064 so C (KOH) = 0.064/2 = 0.032 moldm-3M3: n (H2) = 0.032M4: V (H2) = 0.032 x 8.31 x 298 / 100,000M5: = 0.79 dm3 or 7.9 x 10-4 m3 or 790 cm3[5] |
| **5.** | 2.35 g of sodium hydroxide was dissolved in water and the total volume of solution made up to 250 cm3. 25.0 cm3 of this solution was titrated against 0.20 moldm-3 HCl using a suitable indicator. |
|  | (a) | M1: mr (NaOH) = 40 so n (NaOH) in 25 cm3 = 2.35/40/10 or 2.35/40/0.25\*0.025 = 5.88 x 10-3M2: n (HCl) = 5.88 x 10-3 so V = 5.88 x 10-3 /0.2 = 29.4 cm3 |
|  | (b) | M3: any three from mass balance, burette, pipette, volumetric flaskM4: any three from mb 0.01/2.35 x 100 = 0.43%; b 0.1/29.4 x 100 = 0.34%; p: 0.05/25 x 100 = 0.20%, vf = 0.2/250 x 100 = 0.08% |
|  | (c) | M5: 0.43 + 0.34 + 0.20 + 0.08 = 1.05%M6: 1.05% error gives a range of 0.3 cm3 so 2 – 3 sf suitableMax 5 [5] |

# Section B

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| **B1.** | (a) | M1: n (NaOH) = 0.1 x 0.025 = 0.0025M2: n (H2X) = 0.0025 / 2 = 0.00125M3: C (H2X) = 0.00125 / 0.0184 = 0.0679 and M4: mass concentration of H2X = 2/250 = 8or M3 and M4: n (H2X) in 250 cm3 = 0.00125 x 250 /18.4 = 0.0170M4: mr (H2X) = 8/0.0679 or 2/0.0170 = 118 M5: 118 written to 1 dp max (no rounding errors)[5] |
|  | (b) | M1: MCl2(s) 🡪 M2+(aq) + 2Cl-(aq)M2: Ag+(aq) + Cl-(aq) 🡪 AgCl(s)M3: n (Ag+) = 0.0216 x 0.05 = 0.00108 so n (Cl-) = 0.00108M4: n (MCl2) = 0.00054 M5: C (MCl2) = 0.00054/0.025 = 0.0216 and C (gdm-3) = 1.12/0.25 = 4.48or n (MCl2) = 0.00054 x 10 = 0.0054M6: 1.12/0.0054 or 4.48 / 0.0216 = 207.1M7: M = 136.1 = Ba  [7]  |
|  | (c) | M1: 2MnO4- + 6H+ + 5H2O2 🡪 2Mn2+ + 5O2 + 8H2O M2: n (MnO4-) = 0.0197 x 0.015 = 0.000296M3: n (H2O2) = 0.000296 x 2.5 = 0.000739M4: C (H2O2) = 0.000739/0.025 = 0.0296M5: dilution factor = 250/5 = 50M6: 0.0296 x 50 = 1.48 moldm-3 [6] |
|  | (d) | M1: 2S2O32- + I2 🡪 S4O62- + 2I-M2: n (S2O32-) = 0.0157 x 0.1 = 0.00157M3: n (I2) = 0.00157 / 2 = 0.000785 so n (Cu2+) = 0.000785 x 2 = 0.00157M4: n (Cu2+) in 250 cm3 = 0.00157 x 10 = 0.0157M5: m (Cu2+) = 0.0157 x 63.5 = 0.997 g M6: % Cu = 0.997/1.72 x 100 = 58.0%[6] |
|  | (e) | Estimate the total percentage apparatus error resulting from the titration in part (a) of this question.M1 and M2: any two from: mb – 0.01/2 x 100 = 0.50%, p - 0.05/25 x 100 = 0.20%, b – 0.1/18.4 x 100 = 0.54%, vf – 0.2/250 x 100 = 0.08%M3: 0.50 + 0.20 + 0.54 + 0.08 = 1.32%[3]max 25 marks  |

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| **B2.** | (a) | M1: 10.0 x 1.18 = 11.8 gM2: 0.36 x 1.18 = 4.248 gM3: n (HCl) = 4.248 / 36.5 = 0.116M4: C (HCl) = 0.116 / 0.01 = 11.6 moldm-3M5: -log 11.6 = -1.07[5] |
|  | (b) | eitherM1: dilution factor = 11.6 / 0.1 = 116M2: volume needed = 250/116 = 2.16 cm3M3: mass needed = 2.16 x 1.18 | OrM1: n (HCl) = 0.25 x 0.1 = 0.025M2: m (HCl) = 0.025 x 36.5 = 0.9125M3: m (conc HCl) = 0.9125 x 100 / 36 |
|  |  | M4: = 2.5 (2 sf) or 2.53 (3sf)[4] |
|  | (c) | M1: -log (0.05) = 1.30M2: C (HCl) = 10-1.5 = 0.0316M3: n (HCl) = 0.025 x 0.05 = 0.00125M4: V (HCl) = 0.00125 / 0.0316 = 0.0395 dm3 = 39.5 cm3M5: so 39.5 – 25.0 = 14.5 cm3 water should be addedM6: n (NaOH) = 0.01 x 0.075 = 0.00075M7: n (HCl) remaining = 0.00125 – 0.00075 = 0.0005M8: C (HCl) = 0.0005 / (0.025 + 0.01) = 0.0143 moldm-3M9: pH = 1.85 (or 1.8 if 1 dp)[9] |
|  | (d) | M1: 2HCl 🡪 2H+ + Cl2 + 2eM2: PbO2 + 4H+ + 2e- 🡪 Pb2+ + 2H2OM3: PbO2 + 2HCl + 2H+ 🡪 Pb2+ + 2H2O + Cl2[3] |
|  | (e) | M1: HCl + NH3 🡪 NH4Cl or H+ + NH3 🡪 NH4+M2: CaCO3 + 2HCl 🡪 CaCl2 + CO2 + H2O or CaCO3 + 2H+ 🡪 Ca2+ + CO2 + H2OM3: HCl + NaHCO3 🡪 NaCl + CO2 + H2O or H+ + HCO3- 🡪 CO2 + H2OM4: 2HCl + Mg(OH)2 🡪 MgCl2 + 2H2O or 2H+ + Mg(OH)2 🡪 Mg2+ + 2H2OM5: AgNO3 + HCl 🡪 AgCl + NaNO3 or Ag+ + Cl- 🡪 AgCl[5]max 25 marks |

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| **B3.** | (a) | M1: observations are made about the natural worldM2: attempts are made to explain these observations (hypotheses)M3: as a result predictions are made and testedM4: hypotheses may require alteration or rejection based on testsM5: hypothesis = attempt to explain a scientific observationM6: law = hypothesis which has become sufficiently well supported by evidence to be accepted by the scientific communityM7: theory = description of nature encompassing more than one lawM8: theory = set of laws arrived at by induction; induction = reaching a conclusion based on evidence which provides strong evidence for it but which does not prove it logically M9: theorem = statement arrived at by deduction; deduction = logically proving a conclusion on the basis of other established statements)M10: serendipity = accidental event with favourable consequences[max 9] |
|  | (b) | M1: molarity = moles of solute per dm3 of solutionM2: molality = moles of solute per kg of solventM3: n (C6H12O6) = 90/180 = 0.500M4: molarity = 0.5/0.25 = 2.00 moldm-3M5: mass of solution = 250 x 1.131 = 282.75 gM6: mass of water = 282.75 – 90 = 192.75 gM7: molality = 0.500/192.75 = 2.59 molkg-1 M8: n (C6H12O6) = 22.5/180 = 0.125M9: molarity = 0.125/0.1083 = 1.15 moldm-3M10: mass of water = 0.997 x 100 = 99.7 gM11: molality = 0.125/99.7 = 1.25 molkg-1(max 4 for M1 – M5 and M8 – M9)[8] |
|  | (c) | (i) H2SO4 + 2H+ + 2Br- 🡪 SO2 + Br2 + 2H2OM1 speciesM2 balancedM3 redox(ii) Ba2+(aq) + SO42-(aq) 🡪 BaSO4(s) or H2SO4(aq) + BaCl2(aq) 🡪 BaSO4(s) + 2HCl(aq)M1 speciesM2 state symbols and balancedM3 precipitation(iii) CuO + H2SO4 🡪 CuSO4 + H2O (or ionic)M1 speciesM2 balancedM3 neutralisation or acid-base[9] |