Department of Chemistry

Exam Questions for CfE Higher Chemistry

**MARK SHEME**

Unit 3 Chemistry in Society

**3.1 Getting the Most from Reactants**

|  |  |  |
| --- | --- | --- |
| Question | Source | Answer |
| 1 | 2009 | C |
| 2 | 2011 | C |
| 3 | 2007 | C |
| 4 | 2011 | D |
| 5 | 2012 | A |
| 6 | 2008 | C |
| 7 | 2009 | B |
| 8 | 2013 | A |
| 9 | 2010 | D |
| 10 | 2012 | C |
| 11 | 2013 | A |
| 12 | 2008 | D |
| 13 | 2011 | B |
| 14 | 2010 | C |
| 15 | 2009 | A |
| 16 | 2008 | A |
| 17 | 2009 | A |
| 18 | 2009 | D |
| 19 | 2010 | B |
| 20 | Spec | A |
| 21 | 2013 | B |
| 22 | 2011 | B |

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| Q | Source | Correct |
| 23 | 2007 Q7 | **(a)** Answer to indicate that magnesium hydroxide is insoluble but calcium chloride is soluble, eg magnesium hydroxide is a solid or it precipitates out (can be filtered off) **1**  **(b)** Neutralisation **1**  **(c)** Indication in words or via arrow on diagram that the chlorine produced can be recycled (1)  water from the neutralisation can be recycled (1)  sea water is free or cheap or plentiful or renewable or similar (1)  can sell other products or there are useful biproducts (1) (Any 2 out of 4) **2** |
| 24 | 2011 Q15 | **(a)** precipitation **1**  **(b)** compound Z is water, accept H2O, steam, hydrogen oxide **1**  **(c)** The chlorine gas produced during the electrolysis of cerium chloride can be recycled/ reused (back into stage 4) (in words or indicated on the flow diagram)  **Or** a substance may be added to reduce the temperature at which CeCI3 melts  **Or** CeCl3 can be electrolysed in solution (avoids heating costs for CeCl3(ℓ) electrolysis) **1** |
| 25 | 2011 Q5 |  |
| 26 | 2010 Q12 | moles of LiOH = 0.1 × 0.4 = 0.04 (½)  moles of CO2 = 0.24/24 = 0.01 (½)  0.02 mol of LiOH reacts with 0.01 mol of CO2 (½)  excess LiOH = 0.02 (½) 2 |
| 27 | 2007 Q11 |  |
| 28 | 2009 Q10 |  |
| 29 | 2007 Q14 |  |
| 30 | 2008 Q7 |  |
| 31 | 2012 Q10 | **(a)** It is polar/has hydrogen bonding **1**  **(b) (i)** Methyl methanoate **1**  **(ii)** 58(%) **1**  **(c)** 70(%)  1 mark is for either calculating the theoretical yield, or for working out the numbers of moles of reactant and product formed. eg 1·35(g) or both 0·03 and 0·021  1 mark is for calculating the % yield; either using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant. **2** |

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| 32 | 2013 Q5 | **(a)** 75 % **2**  Total mass of reactants/products = 240 g (1)  Atom Economy = (180/240) × 100 % = 75 % (1)  (Accept 0·75 also, this would be atom economy as a fraction)  **(b)** 40 % **2**  1 mark is given for either calculating the theoretical yield, or for working out the numbers of moles of reactant and product formed. eg 6.55(g) or both 0.0364 and 0.0146  1 mark is given for calculating the % yield; either using the actual and theoretical masses, or using the actual number of moles of products and actual number of moles of reactant. |
| 33 | Spec Q5 | 100% **1** |
| 34 | 2007 Q8 |  |
| 35 | 2009 Q8 |  |
| 36 | 2011 Q8 |  |
| 37 | 2010 Q10 | **(a)** for drying, entry delivery tubes must be below surface of concentrated sulphuric acid and exit tube must be above (1)  for collection, apparatus must be workable (½) and ‘cooler’ labelled (½) eg use of an ice/water bath **2** |

**3.2 Equilibria**

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| --- | --- | --- |
| Question | Source | Answer |
| 1 | 2007 | C |
| 2 | 2007 | B |
| 3 | 2012 | B |
| 4 | 2008 | B |
| 5 | 2008 | C |
| 6 | 2009 | D |
| 7 | 2010 | B |
| 8 | 2010 | C |
| 9 | 2009 | B |
| 10 | 2013 | D |
| 11 | 2013 | C |

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| Q | Source | Correct |
| 12 | 2007 Q11 | **(a)** 2NH3 + 5/2O2 → 2NO + 3H2O (accept multiples) **1**  **(b)** In different state from reactants **1**  **(c)** Increases **1** |
| 13 | 2010 Q3 | **(a) (i)** rate of forward reaction equals rate of reverse reaction  **Or** concentration of reactants and products remain constant **1**  **(ii)** decreases (or reduces or gets smaller or diminishes or lowers) **1**  **(b)** no. of moles = 0.010/32 (½) = 3.125 ×10−4 (0.00031) (½) **1** |
| 14 | 2008 Q10 | **(a)** any suitable indication of point at which curves start to level off on concentration axis, eg by a vertical line or arrow **1**  **(b)** the ratio of moles of reactant (gas): moles of product (gas) is 1:1  **Or** the number of (gaseous) molecules is the same on both sides of the equation **1**  **(c)** propene and cyclopropane curves both level off at the same concentrations as in graph on left hand page; ignore time axis **1** |
| 15 | 2012 Q13 | (a) exothermic **or** Heat given out **or** ΔH < 0 or negative **1**  (ii) Graph shows as pressure increases/concentration C2F4 decreases - Line sloping downward **1** |
| 16 | 2009 Q8 | **(a)** continuous **1**  **(b)(i)** yield decreases at high temperature (½)  idea that equilibrium moves to the left (or to reactant side) at high temperature (½)  or corresponding explanation based on higher yield at lower temperatures **1**  **(ii)** idea that the formation of ammonia decreases the number of molecules (or reduces the pressure) (1)  idea that high pressure causes the equilibrium position to move to right (or product side) or high pressure favours the reaction that reduces the pressure (1) **2** |
| 17 | 2011 Q13 | On addition of NaOH(s)…  OH- react with H+ (½)  concentration of H+ decreases (½)  equilibrium position to shift to the left (½)  CrO42- ion concentration increases (½)  [Any three from the list above for up to 1½]  Final half mark for solution becomes more yellow/ less orange(½) **2** |

**3.3 Chemical Energy**

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| Question | Source | Answer |
| 1 | 2008 | D |
| 2 | 2011 | A |
| 3 | 2013 | A |
| 4 | 2012 | A |
| 5 | 2012 | A |
| 6 | 2009 | A |
| 7 | 2010 | A |
| 8 | 2013 | A |
| 9 | 2012 | D |

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| Q | Source | Correct |
| 10 | 2007 Q5 | **(a)** Endothermic **1**  **(b)** E = mcΔT so 45 = 0·2 × 4·18 × ΔT (½)  ΔT = 53.8 oC (53 or 54) (½)  (Units not required; deduct ½ for incorrect units; deduct ½ for negative sign) **1** |
| 11 | 2012 Q11 | **(a)** 4BF3 + 3NaBH4 2B2H6 + 3NaBF4 (or multiples) **1**  **(b)** -2168 (kJ mol-1) **2**  1 mark for two from the three correct enthalpy change values:  -36 kJ or -1274 kJ or 3 x -286 ( = -858) kJ |
| 12 | 2008 Q14 | **(a)** homogeneous **1**  **(b) (i)** no effect **1** |
| 13 | 2009 Q6 | **(a) (i)** initial and final temperature (or temperature range) (½)  volume (or mass) of water (½) **1**    **(b)** complete combustion (or incomplete combustion in lab method)  **or** richer supply of oxygen (or burns in air in lab method)  **or** no evaporation of methanol **1** |
| 14 | 2013 Q8 | Any two values from -803, 726, 283 (1)  +206 kJ mol-1 (units not required) (1) **2** |
| 15 | 2011 Q14 | **(a)** Answer within range -2640 to -2690 (No units required) **1**  **(b)** E = mcΔT = 0·2 (½ mark) × 4·18 × 40 = 33·44 (½)  74 g gives 33·44 × 74 = 2475/2477 kJ  Enthalpy of comb. = -2475/-2477 (1) (-½ if incorrect sign)  (No units required but deduct ½ for incorrect units) **2**  **(c)** ½ mark for each of the three correctly signed enthalpy change values  +354 (½)  -5 × 394 or -1970 (½)  -6 × 286 or -1716 (½)  Addition -3332 (½) **2**  Only award addition mark if three “sensible” values used.  3 sensible numbers required to get ½ for the addition based on follow through  No units required but deduct ½ for incorrect units |
| 16 | 2012 Q3 | **(a) (i)** 5.75 or 5.77 (g – units not required, ignore incorrect units) **3**  Partial marks can be awarded using a scheme of two “concept” marks, and one “arithmetic” mark  **1 mark** – for demonstration of use of the relationship between specific heat capacity, mass, temperature and heat energy/enthalpy eg Eh = cmΔT or ΔH = -cmΔT  This mark is for concept, do not penalise for incorrect units or incorrect arithmetic.  The value of 171 (kJ) would automatically gain this mark.  **1 mark** – for demonstration of knowledge that the enthalpy of combustion of ethanol relates to the combustion of the gfm of ethanol. This mark could be awarded if the candidate is seen to be working out the number of moles of ethanol required (0.125 or 0.13) or if the candidates working shows a proportion calculation involving use of the gfm for ethanol (46)  This mark is for demonstration of knowledge of this concept, do not penalise for incorrect units of incorrect arithmetic.  **1 mark** – the final mark is awarded for correct arithmetic throughout the calculation but cannot be awarded unless the two concept marks have both been awarded.  **(ii)** Any three from heat lost to surroundings (1)  Incomplete combustion (of alcohol) (1)  Ethanol impure (1)  Loss (of ethanol) through evaporation (1) **3**  **(b)** 1 660 000 (kJ – units not required, ignore incorrect units)  Partial marks:  1 mark for ratio 50/0.00145 or 50000/1.45 or 34500 or 34.5 appearing in working **2** |
| 17 | 2010 Q8 |  |

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| 18 | 2007 Q12 | ΔHc carbon x 2 = -394 kJ x 2 = -788 kJ (½)  ΔHc hydrogen -286 kJ (½)  reverse ΔHc ethyne = +1300 kJ (½)  addition = +226 kJ (½) **2**  (3 ‘sensible’ numbers required for ½ mark for addition based on following through; no units required; deduct ½ for incorrect units) |
| 19 | 2013 Q3 | -97 **2**  A single mark is available if either of the following operations is correctly executed  Either the four relevant values for the bond enthalpies of the C–H, Cl–Cl, C–Cl and H–Cl bonds (or multiples thereof) are retrieved from the databook; 243, 414, 326, 428 (ignore signs) (1)  or the enthalpy values for bond formation are taken away from the enthalpy values for bond breaking without arithmetic error (1) (units not required) |
| 20 | Spec 2 | For 1 mark candidate can have: “432+243” or “675” or “2×428” or “856” or “181”  For 2 marks must have “-181”  **2** |
| 21 | 2008 Q12 | **(a)** the idea that the shape of the reactant (substrate) molecule must fit the enzyme or lock and key diagram(s) **1** |
| 22 | 2009 Q15 |  |
| 23 | 2010 Q14 | **(a) (i)** 2. measure the temperature (of the water) (½)  4. measure the highest temperature reached by the solution (½) **1**  **(ii)** to reduce (or prevent) heat loss to the surroundings or to keep heat in or less energy lost (or to conserve energy) **1**    **(b)** enthalpy change is for the formation of one mole of water or equivalent **1** |

**3.4 Oxidising or Reducing Agents**

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| --- | --- | --- |
| Question | Source | Answer |
| 1 | 2007 | D |
| 2 | 2007 | A |
| 3 | 2008 | D |
| 4 | 2008 | A |
| 5 | 2012 | D |
| 6 | 2009 | C |
| 7 | 2010 | D |
| 8 | 2009 | D |
| 9 | 2011 | C |
| 10 | 2011 | A |
| 11 | 2012 | C |

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| --- | --- | --- |
| Q | Source | Correct |
| 12 | 2008 Q17 | **(a)** MnO4-(aq) + 8H+(aq) + 5e- → Mn2+(aq) + 4H2O(ℓ)  (state symbols not required) **1**  **(b)** there is a colour change from colourless to purple (or purple to colourless)  **Or** the reaction is self-indicating (or a colour change shows the end of the reaction) **1** |
| 13 | 2012 Q5 |  |

**3.5 Chemical Analysis**

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| Question | Source | Answer |
| 1 | 2012 | A |
| 2 | 2012 | C |
| 3 | 2013 | B |
| 4 | 2013 | D |

|  |  |  |
| --- | --- | --- |
| Q | Source | **Correct** |
| 5 | 2007 Q15 |  |
| 6 | 2008 Q17 | **(a)** MnO4-(aq) + 8H+(aq) + 5e- → Mn2+(aq) + 4H2O(ℓ)  (state symbols not required) **1**  **(b)** there is a colour change from colourless to purple (or purple to colourless)  **Or** the reaction is self-indicating  **Or** a colour change shows the end of the reaction **1** |
| 7 | 2009 Q18 | **(a)** 2S2O32-(aq) → S4O62- (aq) + 2e- **1**  (state symbols not required)  **(b)** starch (solution) **1** |
| 8 | 2010 Q16 | **(a)** any 2 (½ mark each) from:  flask should be swirled/ read burette at eye level/ white tile under flask/  add drop-wise (near end-point)/ no air bubble in burette/ titrate slowly/  use an indicator to give a sharp colour change/ rinse with solutions being used/  remove funnel from burette/ put a piece of white paper behind burette/  stir constantly, etc. **1** |
| 9 | 2012 Q13 | **(a)** Looking for two key points  mention of washings/rinsings (1)  make the (standard) flask up to the mark with water (1)/add water until desired volume reached **2** |
| 10 | 2012 Q6 | **(a)** pipette or burette **1**  **(b)** a solution of exactly/accurately known concentration  **or** exact concentration  **or** precise concentration **1** |
| 11 | 2012 Q2 | **(a)** 4 or 4.0 (mg – units not required, ignore incorrect units) **1**  (**b)** 288 g or 288000 mg **2**  Partial marks - 288 or 288000 (1) Correct unit (1)  Eg 34.7 g (1) (awarded for correct unit)  Or 34700 mg (1) (awarded for correct unit) |

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| 12 | 2013 Q10 | **(a)** I2 + 2e– 🡪 2I–  Or I2 + 2e 🡪 2I– **1**  Ignore state symbols  Allowing reversible arrows providing the equation is written the correct way round.  **(b) (i)** first titre is a rough (or approximate) result/practice  **Or** first titre is not accurate/not reliable/rogue  **Or** first titre is too far away from the others  **Or** you take average of concordant/close results **1**    **(iii)** Mass of sodium thiosulfate = 3·96 g (1)  Mention of rinsings (1)  Mention of make up to the mark (1) **3** |
| 13 | Spec Q9 | **(a) (i)** 462·5 or 462·5 mg or 0·462 g **2**  If GFM of KNO2 and NO2 calculated, (85·1 and 46) (1)  Second mark for arith of scaling 250 × 85·1/46 (1)  **(ii)** mention of transfer of rinsings **(1)**  making up to the mark of standard/volumetric flask **(1)**  **(iii)** tap water could contain nitrites  **Or** Distilled water will not contain nitrites (Must mention of nitrites) **1**  **(iv)** Mass required to make 250 cm3 of 0·05 mg l-1 solution is  too small to weigh accurately **1**  **(b)** answer between 0·07 → 0·08 **2**  0·10 (1) (answer found using a valid mean, but not a line of best fit on the graph)  Answer between 0·115 → 0·125 (1) (this answer comes from averaging all of the titres, including the rogue, but then using line of best fit) |
| 14 | 2012 Q9 | **(a)** 69 – 70 (mg l-1 – no units required. Ignore incorrect units) **1**  **(b)** Sample of Y should be diluted  **or** less of sample Y should be used  **or** smaller sample of Y **1** |
| 15 | 2013 Q6 | **(a)** Benzocaine is a smaller/Tetracaine is bigger  **Or** weaker London Dispersion Forces with Benzocaine  **Or** weaker Van der Waal’s forces for Benzocaine  **Or** Benzocaine has lower b.pt  **Or** Benzocaine more soluble/attracted in/ to mobile phase  **Or** Benzocaine less strongly attracted to stationary phase  **Or** Benzocaine is more polar **1**  **(b)** The peaks for lidocaine and caffeine overlap  **Or** Candidate wording for idea of masking **1**  **(c)** Peak for tetracaine at correct RT with approximately half original height **1** |