**A-Level Handbook & Transition Summer Work Chemistry**

**Year 12 > Year 13**

**AS > A-Level**

Uxbridge High School, Science Department



**Name:**

**Target Grade:**

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A-Level Expectations

The second year of your A-Level course is more demanding than the first and requires a greater degree of commitment and independent learning. To enable you to cope with the demands of the course and achieve your target grades, it is essential that you fulfil the following expectations.

* **Attendance = attainment.** Attend all lessons, arrive on time and bring all the necessary books. Do not book appointments during lesson hours.
* Necessary equipment of pens, paper, and your working folders should be brought to **EVERY lesson**.
* Take responsibility for arriving on time to lessons after break or after a free period.
* No mobile phones in use or in view in the lesson.
* Work to the best of your ability in class and focus on the lesson.
* Listen respectfully to the views of other students.
* Complete all homework and classroom work.
* Read widely in your own time, including reading the complete set texts for each component as soon as possible
* Attempt all work. If you are unsure of what to do, of course you may ask questions, but there are times when your teacher will want you to work independently without question. You must respect this.
* Take advantage of any extra lessons/revision sessions.
* Keep to deadlines.

Learner Agreement

As a dedicated student of Chemistry at Uxbridge High School, I promise to meet the expectations above. I understand that not doing so, will result in school sanctions, parent meetings, and most importantly, it will have a negative impact on my attainment.

**Signed \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Print name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Summer Tasks

There is much work to cover in Year 13 as part of your Chemistry A-Level. As such, it is **VITAL** that you begin covering this material over the summer holidays. Completion of the following tasks will ensure that you begin Year 13 in the best way possible, giving yourself the best chance of success.

1. **Finish off work begun.**  
   You began your A-Level Chemistry in the final weeks of the Year 12 summer term. You must now ensure you finish off the following chapters;  
   **Chapter 17 – Thermodynamics, Chapter 21 – Acids, Bases & Buffers.**  
     
   This will involve reading through the chapters in the Kerboodle A-Level AQA Chemistry textbook, and then answering the exam questions in this handbook. Markschemes have been included. It is your responsibility to ensure you understand these chapters thoroughly.
2. **Begin on work to come.**Read through the first two chapters that will be covered upon your return to Year 13 in the Autumn Term; **Chapter 18 – Kinetics, Chapter 22 – Periodicity.**  
     
   You are to make notes on these chapters from the Kerboodle A-Level AQA Chemistry textbook, and answer the summary questions.
3. **Ensure your maths is on par.**There is a greater maths demand in the Chemistry A-Level.  
     
   In the Kerboodle A-Level AQA Chemistry textbook, read through pages 517-524. Ensure you understand the worked examples.

Exam Question & Markschemes

**Chapter 17 – Thermodynamics**

**5.1 THERMODYNAMICS**

Answer all questions

Total 50 marks

**Name:………………………………………………………….**

**Mark for Section A……………./35**

**Mark for section B…………… /15**

**Total: ……………………………. /50**

**Grade……..**

**SECTION A**

**1.** The table below lists a number of mean bond enthalpy values

|  |  |
| --- | --- |
| **Bond** | **Mean bond enthalpy/kJ mol–1** |
| C—C  C==C  C—H  O—H | 348  612  413  463 |

(a) Explain the meaning of the term *mean bond enthalpy*.

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(3)

(b) Given that the enthalpy of combustion to form carbon dioxide and steam is   
–2102 kJ mol–1 for propane and –1977 kJ mo1–1 for propene, determine the enthalpy change for the oxidation of 1 mol of propane to propene and steam

C3H8(g) + ½ O2(g)  C3H6(g) + H2O(g)

using equations or a cycle to support your answer.

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(3)

(c) State the number and type of bonds made and broken in the oxidation of propane to propene and steam. Use the mean bond enthalpies in the table above, together with your answer to part (b), to calculate the bond enthalpy of the O=O bond in the oxygen molecule.

*Bonds broken.*..............................................................................................................

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*Bonds formed*..............................................................................................................

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*Bond enthalpy of* O=O ..............................................................................................

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(4)

(Total 10 marks)

**2.** Sodium bromide is formed from its elements at 298 K according to the equation

Na(s) + Br2(l)  NaBr(s)

The lattice dissociation enthalpy of solid sodium bromide refers to the enthalpy change for the process

NaBr(s)  Na+(g) + Br–(g)

The electron addition enthalpy refers to the process

Br(g) + e–  Br–(g)

Use this information and the data in the table below to answer the questions which follow.



(a) Construct a Born-Haber cycle for sodium bromide. Label the steps in the cycle with symbols like those used above rather than numerical va1ues.

(6)

(b) Use the data above and the Born-Haber cycle in part (a) to calculate the enthalpy of vaporisation, *H*vap of liquid bromine.

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(3)

(Total 9 marks)

**3.** (a)The tablesshow values for the lattice enthalpy of the metal chlorides of the Group 1 and Group 2 metals.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Group 1 metal chloride** | LiCl | NaCl | KCl | RbCl | CsCl |
| **Lattice enthalpy/kJ mol–1** | –846 | –771 | –701 | –675 | –645 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Group 2 metal chloride** | BeCl2 | MgCl2 | CaCl2 | SrCl2 | BaCl2 |
| **Lattice enthalpy/kJ mol–1** | –3006 | –2493 | –2237 | –2112 | –2018 |

(i) Define the term *lattice enthalpy.*

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(2)

(ii) Write the chemical equation for the reaction whose enthalpy change is equal to the lattice enthalpy of NaCl. Include state symbols in your equation.

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(1)

(iii) Explain, in terms of the effects of ionic radius and charge, why the lattice enthalpy of the Group 1 metal chlorides decreases from LiCl to CsCl.

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(3)

(iv) Explain, in terms of the effects of ionic radius and charge, why the lattice enthalpy of MgCl2 is greater than that of NaCl.

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(3)

(Total 9 marks)

**4.** At 298 K, the enthalpy of solution of calcium chloride is –123 kJ mol–1 and the enthalpy

of lattice formation of this salt is –2255 kJ mol–1 The enthalpy of hydration of the calcium ion is -1650 kJ mol–1.

(i) Write equations using calcium chloride or its ions to illustrate the terms *enthalpy of solution, enthalpy of lattice formation* and *enthalpy of hydration.*

*Enthalpy of solution.*.......................................................................................

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*Enthalpy of lattice formation.*.........................................................................

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*Enthalpy of hydration.*....................................................................................

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(ii) Use the data above to determine the enthalpy of hydration of the chloride ion.

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(7)

(Total 7 marks)

**SECTION B**

**5.** Use the data in the table below to answer the following questions.

Give chemical equations and calculate numerical values of *S* wherever possible.

(a) At all temperatures below 100 °C, steam at atmospheric pressure condenses spontaneously to form water. Explain this observation in terms of *G* and calculate the enthalpy of vaporisation of water at 100 °C.

(4)

(b) Explain why the reaction of 1 mol of methane with steam to form carbon monoxide and hydrogen (*H* = +210 kJ mol–1) is spontaneous only at high temperatures.

(6)

(c) Explain why the change of 1 mol of diamond to graphite (*H* = –2 kJ mo1–1) is feasible at all temperatures yet does not occur at room temperature.

(3)

(d) The reaction between 1 mol of calcium oxide and carbon dioxide to form calcium carbonate (*H* = –178 kJ mol–1) ceases to be feasible above a certain temperature, *T*s. Determine the value of *T*s.

(2)



(Total 15 marks)

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**Thermodynamics test ms**

**1.** (a) energy or heat **(1)**  
to break a covalent bond **(1)**  
averaged over several compounds **(1)** 3

(b) propane : C3H8(g) + 5O2(g)  3CO2(g) + 4H2O(g)  
propene : C3H6(g) + 4O2(g)  3CO2(g) + 3H2O(g)  **(1)**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

overall: C3H8(g) + O2(g)  C3H6(g) + H2O(g)

[Or balanced cycle **(1)**]

H = = –2102 + 1977  **(1)**  
= –125 kJ mol–1  **(1)**  3

(c) *Bonds broken* 2 × (C – C) + 8 × (C – H) + (O = O)

or nett : 1 × (C – C) + 2 × (C – H) + (O = O)  **(1)**

*Bonds formed* 1 × (C – C) + 6 × (C – H) + 1 × (C = C) + 2 × (O – H)

or nett : 1 × (C=C) + 2 × (O – H)  **(1)**

*Bond enthalpy of O=O* H = B(bonds broken) – B(bonds formed)  **(1)**

 –125 = B(C – C) + 2B(C – H) + B(O = O) – B(C = C) – 2B(O – H)

 B(O = O) = 2(–125 –348 –2 × 413 + 612 + 2 × 463  
 = +2 × 239 = 478 kJ mol–1 **(1)** 4

[10]

**2.** (a)



6

(b) –Hf + Hsub + Hi + ½Hvap + ½Hdiss + Hea – HL =O **(1)**  
Hvap = 2(Hf – Hsub – Hi – ½Hdiss – Hea + HL) **(1)**  
 = 2 (–361 – 107 – 498 – 97 + 325 + 753)  
 = +30 kJ mol–1 **(1)** 3

[9]

**3.** (i) enthalpy / energy change / energy required / energy evolved   
when 1 mol of ionic solid / crystalline solid / crystals / compound  
/ solid (**not** molecules) (is formed from) **(1)**

its gaseous ions   
(must be stated, **not** transferred by inference from (ii) **(1)** 2

(ii) Na+(g) + Cl–(g) ® NaCl(s)   
allow NaCl(s) ® Na+(g) + Cl–(g) if definition reversed **(1)** 1

(iii) larger (cations) **not** atoms, Li, Na **(1)**

same charge on the cation / ratio of charge:size decreases /   
lower charge density **not** effective nuclear charge **(1)**

therefore weaker attractions between cation and anion **(1)**  
(must clearly mean attraction between cation and anion) 3

(iv) smaller (cations) **not** atoms, Mg, Na   
allow this mark if ‘repeated error’ from (iii) **(1)**

greater charge on the Group 2 cation / ratio of charge:   
size increases / higher charge density **(1)**

therefore stronger attractions between cation and anion **(1)**  
(must clearly mean attraction between cation and anion) 3

[9]

**4.** (i) CaCl2(s)  Ca2+ (aq) + 2Cl- (aq)  **(1)**

Ca2+ (g) + 2Cl– (g)  CaCl2(s)  **(1)**

Ca2+(g)  Ca2+ (aq)  **(1)**

State symbols must be shown

(ii) H/kJ mol–1

CaCl2 (s)  Ca2+ (aq) +2Cl– (aq) –123

Ca2+ (aq)  Ca2+(g) +1650

Ca2+ (g) + 2Cl– (g)  CaCl2 (s) –2255

2Cl– (g)  2Cl– (aq) –728

Hhyd (Cl–(g) =  = –364 kJ mol–1

3 equations **(3)** answer  **(1)**

OR via cycle: 3 steps **(3)** answer  **(1)** 7

[7]

**5.** (a) Steam condenses to water when G  0 **(1)**  
H = TS **(1)**  
S = 189 – 70 = 119 JK–1 mol–1 **(1)**  
H = 373 × 119 = 44 KJ mol–1 **(1)** 4

(b) spontaneous reaction when G  0 **(1)**  
CH4(g) + H2O(g)  CO(g) + 3H2(g) **(1)**  
S = 198 + 3 × 131 – 189 – 186 = 216 JK–1 mol–1 **(1)**  
the entropy change in –TS **(1)**  
makes G -ve once T is high enough **(1)** 6

(c) diamond  graphite S = +3 JK–1 mol–1 **(1)**  
since H  0, G is always  0 **(1)**  
kinetics: large Ea makes reaction too slow **(1)** 3

(d) CaO(s) + CO2(g)  CaCO3(s)  
S = 90 – 40 – 214 = –164 JK– mol–1 **(1)**  
G = 0, H = TS  
Ts =  = 1085 K **(1)** 2

[15]

**Chapter 21 – Acids, Bases & Buffers**

**ACIDS AND BASES**

Answer all questions

Total 50 marks

**Name:………………………………………………………….**

**Mark for section A…………… /35**

**Mark for section C…………… /15**

**Total: ……………………………. /50**

**Grade……..**

**SECTION A**

**1.** (a) (i) Write an expression for the dissociation constant *K*a of propanoic acid, CH3CH2COOH.

*Expression for K*a .............................................................................................

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(ii) Write an expression for p*K*a in terms of *K*a

*Expression for* p*K*a ...........................................................................................

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(iii) Calculate the pH of a 0.10 M solution of propanoic acid, given that  
*K*a = 1.35 × 10–5 mol dm3 for this acid at 25°C.

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(6)

(b) Explain why an aqueous solution containing propanoic acid and its sodium salt constitutes a buffer system able to minimise the effect of added hydrogen ions.

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(3)

(Total 9 marks)

**2.** (a) Write an equation for the reaction which occurs when the weak acid HA is added to water.

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(1)

(b) Write an expression for the dissociation constant, *K*a, for the weak acid HA.

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(1)

(c) The dissociation of the acid HA is an endothermic process. Deduce the effect, if any, of

(i) an increase in temperature on the value of the dissociation constant, *K*a

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(ii) an increase in temperature on the pH of an aqueous solution of the acid

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(iii) an increase in the concentration of the acid on the value of *K*a

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(3)

(d) Identify a compound which could be added to aqueous ethanoic acid so that the pH of the resulting solution would not change significantly if a small volume of dilute hydrochloric acid were added. State the name given to solutions which behave in this way.

*Compound.*..................................................................................................................

*Name.*..........................................................................................................................

(2)

(Total 7 marks)

**3.** (a) At 25**°**C, the constant *K*w has the value 1.00 × 10–14 mol2 dm–6. Define the term *K*w.

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(1)

(b) Define the term *pH.*

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(1)

(c) Calculate the pH at 25 °C of 2.00 M HCl.

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(1)

(d) Calculate the pH at 25 °C of 2.50 M NaOH.

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(2)

(e) Calculate the pH at 25 °C of the solution that results from mixing 19.0 cm3 of 2.00 M HCl with 16.0 cm3 of 2.50 M NaOH.

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(6)

(Total 11 marks)

**4.** Methylamine is a weak Brønsted-Lowry base and can be used in aqueous solution with one other substance to prepare a basic buffer.

(i) Explain the term *Br*ø*nsted-Lowry base* and write an equation for the reaction of methylamine with water to produce an alkaline solution.

*Brønsted-Lowry base* ...................................................................................

*Equation* .......................................................................................................

(ii) Suggest a substance that could be added to aqueous methylamine to produce a basic buffer.

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(iii) Explain how the buffer solution in part (a)(ii) is able to resist a change in pH when a small amount of sodium hydroxide is added.

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(5)

(Total 5 marks)

**5.** The pH curve for the titration of the weak diprotic acid H 2SO3 with aqueous sodium hydroxide is shown below.



(i) Identify the sodium salt formed from H 2SO3 when *x* cm3 of NaOH have been added.

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(ii) Write an equation for the reaction that occurs between the two end-points (equivalence points).

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(iii) Name an indicator which could be used to determine the second end-point (equivalence point).

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(3)

(Total 3 marks)

**SECTION B**

**6.** A 0.210 mol dm–3 solution of potassium hydroxide was added from a burette to 25.0 cm3 of a 0.160 mol dm–3 solution of ethanoic acid in a conical flask.  
Given that the value of the acid dissociation constant, *K*a, for ethanoic acid is 1.74 × 10–5 mol dm–3, calculate the pH at 25 °C of the solution in the conical flask at the following three points:

before any potassium hydroxide had been added;

after 8.0 cm3 of potassium hydroxide solution had been added;

after 40.0 cm3 of potassium hydroxide solution had been added.

(Total 15 marks)

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**ACIDS AND BASES - ANSWERS TO EXAM QUESTIONS**

**1.** (a) (i) A proton donor  **(1)**

(ii) Fully ionised or fully dissociated  **(1)**

(iii) 10 × 10–14  **(1)**

mol2 dm–6  **(1)** 4

(b) (i) 150 × 10–3/25 × 1000  **(1)**

= 006 mol dm–3  **(1)**

12  **(1)**

(ii) Mol OH– added = 50 × 0150/1000 = 75 × 10–3 **(1)**

Mol H+ used = 15 × 10–3 **(1)**

Mol OH– excess = 60 × 10–3 **(1)**

[OH–]= 60×10–3/75×1000 = 80 × 10–2 **(1)**

[H+] = 10–14/80×10–2 = 125 × 10–13 **(1)**

pH = 129 **(1)**

8

(c) (i) 03 mol dm–3 **(1)**

(ii) [H+] at pH = 07 is 02 mol dm–3 **(1)**

m1 v1 = m2 v2  03 × 25 = 02 × v **(1)**

Hence v = 375 **(1)**

Water added = 375 – 25 = 125 **(1)**

5

[17]

**2.** (a) (i) *K*a =  **(1)**

*K*a =   **(1)**

[H+] = 10–2.82 = 1.514 × 10–3 mol dm–3  **(1)**

*K*a =  = 1.53 × 10–5  **(1)** mol dm –3 **(1)** [2]

(ii) Decreases  **(1)**

Equilibrium shifts to right (endothermic process )  **(1)**

 [H+] as T **(1)**

pH gets smaller 8

(b) (i) n  **(1)**

(ii)   **(1)** = 2  **(1)**

(iii) *K*a =   **(1)**

= 2.1 × 10–4 mol dm –3  **(1)** 5

(c) Weak acid/strong base pH at equivalence  7  **(1)**

methyl orange has colour change at pH  7  **(1)** 2

(d) Buffer can resist change in pH  **(1)**

on addition of small amounts of H+ (or OH–)  **(1)**

H+ (aq) + X– (aq)  HX (aq)  **(1)** 3

[18]

**3.** (a) proton donor **(1)**  
substance formed when acid has lost proton / substance that  
becomes an acid  
by gaining a proton (**not** just proton acceptor)  **(1)** 2

(b) (i) acid: HBr base: Br–

(ii) acid: H2SO4 base: HSO4–

allow 1 in (b) if both acids / bases are correct (ie give 1 for a correct  
vertical pair) 2

(c) (i) H2O  H+ + OH– / 2H2O  H3O+ + OH– **(1)**  
(accept other types of arrow) 1

(ii) *K*c =  / expression based on H3O+ equation **(1)**  
[H2O] is (effectively) constant /concentration of H2O is large /  
equilibrium in (i) is to left **(1)**

(*Kc* × [H2O]) = *Kw* = [H+] [OH–] **(1)** 3

(iii) [H+] = [OH–] / [H+]2 = 2.92 × 10–14 **(1)**

[H+] = 2.92 × 10–14 = 1.71 × 10–7 **(1)**

pH = –log10(1.71 × 10–7) **(1)**

= 6.77 **(1)** 4

(iv) endothermic **and** attempt at reason **(1)**

more dissociation / ionization / H+ ions at higher temperature **(1)**

if (iii) not completed, allow endothermic with sensible reason  
for 1 mark if answer to (iii) is pH>7, allow 1 mark for exothermic  
with attempt at reason 2

[14]

**4.** (a) *Definition of a base* Proton acceptor **(1)**

*Essential feature* Transfer of protons **(1)**

*Equation* H+ + OH–  H2O  
 OR H+ + B  BH+ **(1)** 3

(b) only partially dissociated in solution **(1)** 1

(c) *K*a =  **(1)**

mol dm–3 **(1)** 2

(d) (i) resists change in pH **(1)**  
on addition of small amounts of strong acid or base **(1)**

(ii) correct weak acid/co-base  
or correct weak base/co-acid **(1)**

(iii) any suitable use **(1)** 4

[10]

**5.** (a) (i) 0.12 × 11.8 = M × 25 **(1)**  
molarity = 0.057 **(1)**

(ii) Ka =  **(1)**

(iii) *Volume of NaOH(aq) added* 11.8/2 = 5.9 cm3 **(1)**

*pH* 4.3 to 4.35 **(1)**

(iv) As [HA] = [A–] **(1)** Ka = [H+] **(1)**  
pH = – log10 [H+] **(1)** hence Ka = 10–4.3  
= 5.0 × 10–5 **(1)**  
Note:– Mark Ka consequentially to pH in a(iii) 9

(b) (i) The added OH– reacts with HA or H+ **(1)**  
The equilibrium, HA  H+ + A– , displacement to right  
or HA ionises **(1)**

(ii) The added H+ reacts with A– **(1)**  
The equilibrium, HA  H+ + A–, displaced to left **(1)** 4

[13]

**6.** (a) CO + H+  HCO or Na2CO3 + HCl  NaHCO3 + NaCl **(1)**

HCO + H+  H2O + CO2 or NaHCO3 + HCl  NaCl + CO2 + H2O **(1)** or H2CO3

2

(b) 15 cm3 1

(c) *Indicator*  Methyl orange (allow other correct indicators) **(1)**

*Explanation* Methyl red changes colour over pH  
 range 3.2 – 4.4 (allow between 3 and 7) **(1)** 2

(d) CO + 2H+  H2O + CO2

Mol H+ = 30 × 0.12/1000 = 3.6 × 10–3 **(1)**

Mol CO = 1.8 × 10–3 = M × 25/1000 **(1)**

= 0.072 M **(1)** 3

(e) *Volume of HCl(aq) added for first end-point* 15 **(1)**

*Volume of HCl(aq) added for second end-point* 45 **(1)** 2

[10]

**7.** (a) A proton donor 1

(b) *Equation* HCl(g) + H2O(l)  H3O+(aq) + Cl–(aq) **(1)**

*Role of water* base or proton acceptor **(1)** 2

(c) *Equation* NH3(g) + H2O(l)  NH(aq) + OH–(aq) **(1)**

*Role of water* acid or proton donor **(1)** 2

(d) *Equation for formation* H2SO4 + HNO3  HSO + H2NO **(1)**

*Role of nitric acid* base or proton acceptor **(1)**

H2NO  NO + H2O **(1)** 3

(e) (i) only partially dissociated in aqueous solution **(1)**

(ii) *K*a =  **(1)**

(iii) not very big **(1)**

(iv) strong **(1)**

Although HX is not fully dissociated, the relative  
concentration of undissociated HX is very small **(1)** 5

[13]

**8.** (a) NaOH + HA  NaA + H2O **(1)**

or HA + OH–  A– + H2O 1

(b) (i) Moles A– = moles NaOH added **(1)**

= 15 × 0.34 × 10–3 = 5.10 × 10–3 **(1)**

Initial moles HA = 25 × 0.45 × 10–3 = 0.01125 **(1)**

*Allow 0.0110 – 0.0113*

Moles NaOH added = 0.00510

Moles HA remaining = 6.15 × 10–3 **(1)**

*Allow (5.90 – 6.20) ×10–3*

*Mark conseq*

(ii) 5.10×10–3 moles A– in (15 + 25) cm3  
Hence [A–] = 5.10 × 10–3 × 1000/40 = 0.1275 **(1)**

*Allow0.127 –0.128 and 0.13*

6.15 × 10–3 moles HA in 40 cm3

Hence [HA] = 6.15 × 10–3 × 1000/40 = 0.1538 **(1)**

*Allow 0.147 – 0.155 and 0.15*

Allow marks in (ii) conseq to answers in (i)

(iii) Ka = [H+] [A–] / [HA] = 2.00 × 10–4  
[H+] = 2.00 × 10–4 × 0.1538 / 0.1275 **(1)**  
 = 2.41 × 10–4 **(1)**

*Allow (2.29 – 2.44) × 10–4*

pH = 3.62 **(1)**

*Allow 3.61 – 3.64 and 3.6*

*Mark conseq to answers in (ii)* 9

[10]

**9.** (a) only partially ionized / partially dissociated / not fully ionised **(1)**  
**not** ‘not ionised at all’ 1

(b) (i) *Ka* =  **(1)**

accept [H+]  
do not accept with [H2O] included  
must include charges 1

(ii) p*Ka* = – log *Ka* **(1)**  
allow – log (*Ka*) do not allow – log [*Ka*] 1

(iii) p*Ka* = 10 (ignore units) **(1)** 1

(iv) lower / smaller number **(1)** 1

(c) (i) at end point pH = p*Ka* = 9.3 **(1)**

colour change detectable over range of 2 pH unitsrange = 8.3 10.3 **(1)**  
(allow 8 – 10) 2

(ii) (colourless to) pink / red **(1)**

[In–] [HIn] / [In–] increases **(1)**  
**not** just equilibrium shifts to right 2

(iii) equivalence point / end point of titration below pH 7 more acidic / lower  
than phenolphthalein range / is about pH 4 **(1)**  
**not** justthe pH range is wrong 1

[10]

**10.** (a) (i) pH = –log(10) [H+] Note; (aq) not required; Not –ln [H+] **(1)**

(ii) Ka = [H+] [X–] / [HX] Note; (aq) not required **(1)**

*Allow [A–] and [HA]*

Do NOT allow [H+]2/[HX]

(iii) Ka = 4.25 × 10–5 = [H+]2/[HX] **(1)**

[H+] =  **(1)**

= 4.37 × 10–3 **(1)**

*not a conseq mark*

pH = 2.36 Mark conseq to [H+] above **(1)**

or pH = pKa –log10 [HX] =  × 4.37 +  × 0.346 = 2.36  
 **(1)** (2) **(1)**

Note pH = 2.4 scores max 3 6

(b) (i) [H+] = 0.25 × 0.95 = 0.2375 **(1)**

*Allow 0.237 – 0.238 and 0.24*

pH = 0.62 **(1)**

*Allow 0.62 – 0.63*

Only allow pH mark if [H+] is correct

(ii) [H+] = [Y–] = 0.2375 (or a value from b(i)) **(1)**

[HY] = 0.05 × 0.25 = 0.0125 **(1)**

*Allow 0.012 – 0.013*

Ka = [H+] [Y–] / [HY]

= (0.2375)2 / 0.0125 **(1)**

Ka = 4.51 **(1)**

*Allow 4.3 – 4.8*

*Ignore units*

*CE if [HY] is incorrect* 6

[12]

**11.** (a) pKa + –log10 Ka 1

(b) Ka = 1.90×10–4 **(1)**

Ka = [H+]2/0.52 or [H+]=[X–] **(1)**

[H+] = (1.90×10–4×0.52) = 9.94×10–3 **(1)**

pH = –log10 [H+] = 2.00 **(1)**

or pH = ½ pKa –½ log [HX]

= 1.86 –(–0.142) = 2.00 4

(c) Ka [H+] [X–]/[HX] **(1)**

[HX] = [X–] at half neutralisation **(1)**

Hence Ka= [H+] and pKa = pH **(1)** 3

(d) There is no rapid/sharp/steep change in pH during a weak  
acid - weak base titration **(1)**

Indicator need a sharp pH rise to change colour quickly **(1)** 2

[10]

**12.** (a) (i) Ka =  **(1)**

(ii) (1) Ka =  **(1)**(2) [H+] =  = 1.96 × 10–3 **(1)**  
(3) pH = -log10[H+] **(1)**

can score independently

(4) pH = 2.71 **(1)**

2 d.p. essential  
If forget  can score (1) and (3) for pH = 5.42

5

(b) (i) moles acid = × 0220 **(1)** = 5.50 ×10–3  
 =  × 0.150  
 *x* = 25 ×  **or** 5.50 × 10–3 ×   
 = 36.7 (or 37) cm3 (or 36.6) **(1)**

NOT 36 NOR 37.0  
units must match

(ii) *Indicator*: thymol blue **(1)***Explanation*: weak acid – strong base **(1)** equivalent at pH  7 **(1)** or high pH 5

(c) (1) mol NaOH added =  = 0.050 **(1)**

If wrong Mr: CE  lose marks (1) and (2) then mark on  
consequentially  max 4

(2) mol CH3COOH left = 0.220 - 0.050 = 0.170 **(1)**

(3) mol CH3COO– formed = 0.050 **(1)**

(4) [H+] = Ka  OR pH = pKa +  etc **(1)**

If expression wrong no marks for 4 / 5 / 6

can score (1) to (4) in (5)

(5) [H+] = 1.74 × 10–5 ×  OR pH = 4.76 + log **(1)**

(6) pH = 4.23 **(1)**

Correct answer gets    
Mark (5) is for use of correct values of (acid moles) and  
(salt moles)  
if one wrong allow pH conseq  
if both wrong, no further marks  
e.g. if candidate forgets substitution in (2)  
he loses (2) and (5) but can score (1) (3) (4) (6) = max 4  
for pH = 4.12 if  upside down; answer 5.29 scores 3  
for (1) (2) (3)

6

[16]

**13.** (a) moles HA =  × 0.150 = 3.75 × 10–3 **(1)** vol NaOH =  = 1.875 × 10–2 dm3 **(1)**

or 18.75 cm3

2

(b) (i) pH = –log10 [H+] **(1)**

(ii) Value above 7 but below 11 **(1)**

(iii) phenol red / thymol blue / phenolphthalein / thymolphthalein

i.e. indicator with 7 < pKin <11

3

(c) (i) Only slightly dissociated **(1)**

NOT “not fully dissociated / ionised”

(ii) Ka =  **(1)**

NOT 

(iii) For weak acid alone:  
Ka = **** **(1)  
** [H+] =   
 = 2.03 × 10–3 **(1)** pH = 2.69 **(1)**

pH should be given to 2 decimal places  
penalise answer to 1 d.p. once in question

5

(d) moles OH– added = 1.875 × 10–3 = moles A– = moles HA left **(1)  
or**  [A–] = [HA]  
 Ka = [H+] **or** pH = pKa **(1)** pH = 4.56 **(1)** 3

[13]

**14.** Penalise pH given to 1 dp first time it would have scored only

(a) (i) Kw = [H+] [OH–] **(1)**

(ii) pH = –log [H+] **(1)**

or in words or below unless contradiction

(iii) *Calculation*: [H+] =  **(1)**  
 = 2.34 × 10–7  
  pH = 6.63 or 6.64 **(1)**

*Explanation*: pure water  [H+] = [OH–] **(1)** 5

(b) (i) [OH–] = 0.150  [H+] = 10–14/0.15 = 6.66 × 10–14  
 or pOH = 0.82

 pH = 13.18 **(1)**  
 or pH= 13.17

(ii) moles OH– = (35 × 10–3) × 0.150 = 5.25 × 10–3 **(1)**a

moles H+ = (40 × 10–3) × 0.120 = 4.8(0) × 10–3 **(1)**b

 excess moles of OH– = 4.5 × 10–4 **(1)**c

 [OH–] = (4.5(0) × 10–4) × 1000/75d **(1)e**

[H+] =  = 1.66 × 10–12 or pOH = 2.22

 pH = 11.78 **(1)**f  
or 11.77 8

(c) (i) Ka =  **(1)**

(ii) [H+] = 1.80 × 10–2 × 0.150 = 2.70 × 10–3 (1)

Ka =  = 4.86 × 10–5 **(1)** mol dm–3 **(1)** 5

or  = 4.95 × 10–5

**Notes**

(a) If Kw includes H2O allow 6.63 if seen otherwise no marks likely

(b) (ii) If no vol, max 4 for a, b, c, f answr = 10.65  
If wrong volume max 5 for a, b, c, e, f  
If no substraction max 3 for a, b, d  
If missing 1000 max 5 for a, b, c, d, f answer = 8.78  
If uses excess as acid, max 4 for a, b, d, f answer = 2.22  
If uses excess as acid and no volume, max 2 for a, b answer = 3.35

(c) If wrong Ka in (i) max 2 in part (ii) for [H+] **(1)** and conseq units **(1)**

but mark on fully from minor errors  
eg no [ ] or charges missing

[18]

**15.** (a) Hydrogen bonding **(1)**  
between H2O and NH3 **(1)** 2

(b) (i) NH3 + H2O  NH4+ + OH– **(1)**

(ii) Ammonia is weak base **(1)**

NOT partially ionised

Equilibrium to left or incomplete reaction **(1)** 3

(c) A proton donor **(1)** 1

(d) *Buffer solution*: A solution which resists change in pH **(1)**when small amounts of acid or base added or on dilution **(1)**

*Reagent*: NH4Cl **(1)** 3

Allow a correct strong acid

(e) (i) Ka = [H+] [A–] / [HA] **(1)**  
 = [H+] [0.125 × 4] **(1)** / 1.00  
[H+] = 1.70 × 10–5 / 0.125 × 4 = 3.40 × 10–5 **(1)**

pH = –log10 [H+] = 4.47 **(1)**

Allow pH conseq to [H+] if 2 place decimals given

(ii) H+ + CH3COO–  CH3COOH **(1)** 5

[14]

**16.** (a) Ka =  1

(All three sets of square brackets needed, penalise missing brackets or missing charge once in the question)  
(Don’t penalise extra [H+]2/[HA])

(b) Ka =  or [H+] = [A–] 1  
[H+] =   
 = 6.02 × 10–3 1  
pH = 2.22 1

(must be to 2dp)  
(allow 4th mark consequential on their [H+])

1

(c) (i) pH (almost) unchanged 1

(Must be correct to score explanation)

H+ removed by A– forming HA  
or acid reacts with salt  
or more HA formed 1

(ii) [H+] = 10–3.59 = 2.57 × 10–4 or 2.6 × 10–4 1  
[A–] =  1  
 =  1  
 = 0.141 (mol dm3) 1

(Allow 0.139 to 0.141 and allow 0.14)

(If not used 3.59, to find [H+] can only score M2 for working)

(If 3.59 used but [H+] is wrong, can score M2 for correct method and conseq M4)

If wrong method and wrong expression, can only score M1)

(ii) *Alternative scheme for first three marks of part (c)(ii)*

pH = pKa  log 1

pKa = 3.84 1

3.59 = 3.84 – log 1

[11]

**17.** (a) (i) pH = –log [H+] **(1)**

(ii) *Expression for Ka*: Ka =  **(1)**

*Calculation*: pH = 2.56  [H+] = 2.75 × 10–3 **(1)**  
Ka =  =  = 6.32 × 10–5 **(1)** (mol dm–3)  
or [H+] = [X–] **(1)** 5

depending on approximate made, values of Ka = 10–5 ×  
using [HX] = 0.12 6.30 – 6.32  
using [HX] = 0.12 – 2.75... 6.45 – 6.47  
using 2.8 and [HX] = 0.12 6.53  
using 2.8 and [HX] = 0.12 – 2.8 6.69  
upside down Ka

(b) (i) *Expression for Kw*: Kw = [H+] [OH–] **(1)**

*Value of Kw*: (1.0 ×)10–14 (mol2 dm–6) **(1)**

ignore units

(ii) [H+] =  = 2.22 × 10–13

or pOH = 1.35 **(1)**

 pH = 12.65 **(1)** 4

must be 2dp in final answer

(c) (i) H2C2O4 + OH–  HC2O4– + H2O **(1)**

(ii) mol OH– = (41.6 × 10–3) × 0.0450 **(1)** = 1.87 × 10–3  
 mol H2C2O4 = 9.36 × 10–4 **(1)**[H2C2O4] = 9.36 × 10–4 × 103/25  
 = 0.0374 **(1)** 4

if moles of H2C2O4 not equal to half moles of OH–, no further marks gained

if mol OH– = 1.9 × 10–3; hence mol H2C2O4 = 9.5 × 10–4; [H2C2O4] = 0.038

[13]

**18.** (a) (i) B; 1

C; 1

A; 1

(ii) cresolphthalein

*OR*

thymolphthalein; 1

(b) (i) –log[H+]; 1

(ii) [H+] = 1.259 × 10–12 (or 1.26 or 1.3) *OR* pOH = 14 – pH; 1

 *OR* = 2.10; 1

= 7.9(4) × 10–3; 1

(if [H+] is wrong allow 1 for [OH] = KW/[H+] or as numbers)

(c) (i) Ka = [H+]2/[CH3CH2COOH]

*OR*

[H+]2/[HA]

*OR*

[H+] = [A–] etc; 1

[H+] = l.35×l0–5 × 0.117 or expression without numbers; 1

= 1.257 × l0–3

pH = 2.90; 1

(iii) Ka = [H+]

*OR*

pKa = pH; 1

pH = 4.87; 1

(penalise 1dp once)

[13]

**19.** (a) –log [H+] 1  
4.57 × 10–3 1

allow 4.6 × 10–3

ecf if [ ] wrong and already penalised

ignore units

(b) (i) K*a* =  allow HA etc

not  but mark on

If expression wrong allow conseq units in (ii) but no other marks in (ii) 1

(ii) =  1

If use 4.6 × 10–3

Ka = 1.4(1) × 10–4 and pKa = 3.85 1

= 1.39 × 10–4

allow 1.39 – 1.41 × 10–4

mol dm–3

(iii) *pK*a = 3.86 1

Penalise dp of final answer < or > 2 in pH once in paper

(c) (i)  × 0.480 = 0.0144 or 1.4(4) ×10–2 1

Mark is for answer (M1)

(ii)  × 0.350 = 0.0063 or 6.3 × 10–3 1

Mark is for answer (M2)

(iii) 0.0144 – 2(0.0063) = 1.80 × 10–3 1

M3 is for (i) – 2(ii)

If x 2 missed, CE i.e. lose M3 and the next mark gained

(iv) 1.80 × 10–3 ×  = 0.0375 (0.038) 1

M4 is for answer

If vol is not 48 × 10–3 (unless AE) lose M4 and next mark gainedIf multiply by 48 - this is AE - i.e. lose only M4  
If multiply by 48 × 10–3 this is AE - i.e. lose only M4

(v) 10–14 / 0.0375 (10–14 / 0.038) 1

M5 for Kw/[OH–]

(= 2.66 × 10–13) (= 2.63 × 10–13) 1

or pOH

or pOH = 1.426 (or pOH = 1.420)

If no attempt to use Kw or pOH lose both M5 and M6

pH = 12.57 (12.58) M6 1

Allow M6 conseq on AE in M5 if method OK

[13]

**20.** (a) (i) [H+][OH–] 1

– log [H+] 1

(ii) [H+] = [OH–] 1

(iii) (2.0 × 10–3) × 0.5 = 1.0 × 10–3 1

(iv) [H+] =  ( = 4.02 × 10–11) 1

pH = 10.40 1

(b) (i) Ka = [H+][CH3CH2COO–] 1

[CH3CH2COOH]

= [H+] 1

[CH3CH2COOH]

[H+] = √(1.35 × 10–5) × 0.125 ( = 1.30 × 10–3) 1

pH = 2.89 1

(c) (i) (50.0 × 10–3) × 0.125 = 6.25 × 10–3 1

(ii) (6.25 × 10–3) – (1.0 × 10–3) = 5.25 × 10–3 1

(iii) mol salt formed = 1.0 × 10–3 1

(H+) = Ka × [CH3CH2COOH] 1

[CH3CH2COO–)

= (1.35 × 10–5) × ( = 7.088 × 10–5) 1

pH = 4.15 1

[16]

**21.** (a) Concentration of acid: m1v1 = m2v2 hence 25 × m1 = 18.2 × 0.150

OR

moles NaOH = 2.73 ×10–3; 1

m1 = 18.2 × 0.150/25= 0.109; 1

(b) (i) *K*a=[H+][A–]/[HA] *not* *K*a= [H+]2 / [HA]; 1

(ii) pKa = –logKa; 1

(iii) [A–] = [HA]; 1

hence *K*a= [H+] [A–] / [HA] = [H+]

and –logKa = –log[H+]; 1

(c) ratio [A–] : [HA] remains constant; 1  
hence as [H+] *= K*a[HA] / [A–]; [H+] remains constant; 1

(d) (i) pH of 0.250 mol dm-3 HCl = 0.60  
and pH of 0.150 mol dm-3 HCl = 0.82; 1  
pH change = 0.22; 1

(ii) moles HCl = 30 × 0.250 × 10–3 = v × 0.150 × 10–3 = 7.50 × 10–3

OR

v =30 × 0.250 × 10–3/ 0.150 × 10–3 =50; 1

water added = 50 – 30 = 20 cm3; 1

[12]

**22.** (a) proton or H+ donor **(1)** 1

(b) (i) partially ionised or dissociated **(1)**

*not fully*

(ii) NH3 **(1)**

*not NH4OH – but allow in equation*

*not H2O – but allow in equation if both weak acid and base stated*

NH3 + H2O   + OH– **(1)** 3

(c) (i) HCOOH(aq) + H2O(l)  HCOO–(aq) + H3O+(aq) **(1)**

*allow H2O(aq)*

(ii) H2O or water **(1)**  
HCOO– or methanoate ion **(1)**

(iii)  **(1)**

allow [OH3+] 4

(d) (i) addition of small amounts of acid **(1)**  
addition of small amounts of base **(1)**

*allow volumes, allow alkali, penalise missing small once only not weak*

dilution **(1)**

(ii) sodium methanoate or sodium hydroxide **(1)**

allow salt of methanoic (or this) acid not just an ion (methanoate)

(iii) OH– added **(1)**

*or base*

H+ reacts with OH– **(1)**

*or forming water*

More HCOOH dissociates to restore equilibrium **(1)**

*allow equilibrium moves to right*

*must only describe addition of base;*

*if both base and acid addition given, MAX 1 ex 3* 7

[15]

**23.** (a) HCl(g) + H2O(l)  H3O+(aq) + Cl–(aq) **(1)**

*allow H2O(aq)* 1

(b) pH = –log[H+] **(1)**  
= –0.10 ( 0.01) **(1)** 2

(c) pH = 7 **(1)**  
neutral solution or [H+] = [OH–] **(1)** 2

(d) (i) moles H+ = 1.26 ×  moles **(1)**

*range 0.120  0.001*

(ii) moles OH– = 2 × 1.37 ×  = 0.1233 moles **(1)**

*range 0.123  0.001*

(iii) XS OH– = 0.1233 – 0.1197 = 3.6 × 10–3 moles **(1)**

*range 0.001 to 0.005*

Volume = 95 + 45 = 140 cm3 **(1)**

 [OH–] = 3.6 × 10–3 ×  = 0.0257 M **(1)**

*range 0.0071 to 0.0357*

Kw = [H+] [OH–] = 10–14 mol2 dm–6 **(1)**

 [H+] =  = 3.89 × 10–13 M **(1)**

*range (0.28 to 1.35) × 10–12*

 pH = 12.41 **(1)**

*must show 2 dp range 11.87 to 12.55* 8

[13]

*If no × 2 for Ba(OH)2 then H+ is in XS* *MAX 4 ex 6*

*If no volume used then* *MAX 4 ex 6*

*If no × 1000 for molarity then*  *MAX 4 ex 6*

*Combinations of TWO of these* *MAX 2 ex 6*

*All THREE*  *ZERO*

**24.** (a) only partially dissociated in water 1

(b) (i) Added H+ reacts with A– **(1)**

Equilibrium moves left

& HA forms, restoring [H+] and pH **(1)**

(ii) Added OH– reacts with H+ forming H2O **(1)**

Equilibrium moves right

& HA dissociates, restoring [H+] and pH **(1)** 4

(c) (i) Ka =  1

(ii) Equation for [H+] [H+] = Ka ×  **(1)**

[HA] and [A–] **(1)**

are altered to same extent

maintaining [H+] and pH **(1)** 3

[9]

**25.** (a) (i) pKa = –log10Ka **(1)**

(ii) 6.31 × 10–5 **(1)**  
mol dm–3 **(1)**

(iii) [H+] = [A–] or Ka = [H+]2/[HA] **(1)**  
Hence 6.31 × 10–5 = [H+]2/0.830  
[H+] = (6.31 × 10–5 × 0.830) = 7.24 × 10–3 **(1)**  
pH = –log10[H+] **(1)**  
pH = 2.14 **(1)**  
Marked consequentially to a(ii) 7

(b) (i) Mol NaOH = mol X– **(1)**  
mv/1000 = 0.800 × 10.5/1000 = 8.4 × 10–3 **(1)**

(ii) Mol HX remaining = original mol HX – mol NaOH added **(1)**  
(25 × 0.92/1000) – 8.4 × 10–3 = 0.0146 **(1)**

(iii) *Concentration of X–* 8.4 × 10–3 × 1000/(25 + 10.5)  
 = 0.237 **(1)**

*Concentration of HX* 0.0146 × 1000/35.5  
 = 0.411 **(1)**

*pH of solution* Ka = [H+] [X–]/[HX] **(1)**  
 [H+] = 5.25 × 10–5 × 0.411/0.237 **(1)**  
 pH = 4.04 **(1)**  
 Marked consequentially to b(iii) 9

(c) *Change in pH* Very small fall or slight change **(1)**

*Explanation* H+ + X–  HX **(1)**  
 Equilibrium restored HX  H+ + X– OR 3

[19]

**26.** (a) *Monoprotic acid* An acid which gives only one proton **(1)**  
*Example* HCl etc **(1)** 2

(b) (i) – log10[H+] or in words **(1)**

(ii) 1.58 M (allow 1.6) **(1)** 2

(c) Mol H+ = 25 × 0.15 × 10–3 **(1)** = 3.75 × 10–3  
Mol OH– = 35 × 0.12 × 10–3 **(1)** = 4.20 × 10–3  
Excess OH– = 4.5 × 10–4 **(1)**  
[OH–] = 4.5 × 10–4 × 1000/60 **(1)** = 7.5 × 10–3  
[H+] = 10–14/7.5 × 10–3 **(1)** =1.33 × 10–12 **(1)**  
pH = – log10 1.33 × 10 –12  
= 11.9 **(1)**

NB Consequential marking if [OH–] not calculated to maximum of 5 7

[11]

**27.** (a) *Equation for HCl(g)* HCl(g)  H+(aq) + Cl–(aq) **(1)**

*Equation for KOH(s)* KOH(s)  K+(aq) +OH–(aq) **(1)** 2

(b) *K*w = [H+] [OH–] 1

(c) strong base, fully dissociated **(1)** or [OH–] = 0.016 M **(1)**

[H+] =  **(1)** =  = 6.25 × 10–13 M **(1)** **(2)**

pH = –log10[H+] **(1)**

 pH = 12.2 **(1)**

neutral solution,  [H+] = [OH–] **(1)**

 pH = 7 **(1)** 7

(d) (i) 755 cm3 of 0.012 M acid contain

 mol H+ = 9.06 × 10–3 moles **(1)**

 moles OH– used for neutralisation = 9.06 × 10–3 **(1)**

(ii) pH = 11.6  [H+] = 10–11.6 = 2.5 × 10–12 M **(1)**

[OH–] = =  **(1)**  [OH–] = 3.98 × 10–3 M **(1) (2)**

in 755 cm3 there are 

= 3.0 × 103 mol **(1)**

(iii) Total moles = (9.06 + 3.0) × 10–3 = 0.012 mol **(1)**

(iv) *M*r = 39 + 16 + 1 = 56

 m = 56 × 0.012 = 0.68g **(1)** 8

[18]

**28.** (a) HF + H2O  H3O+ + F– **(1)**

HCl + H2O  H3O+ + Cl– **(1)** 2

for HF, must have reversible arrow  
allow (aq) in HCl equation

(b) (i) pH = –log10[H+] **or** equivalent word definition **(1)** 1

allow -log[H3O+] **or** -log[H+(aq)]

(ii) [H+]= 0.050 mol dm–3

pH = 1.3(0) **(1)** 1

if correct definition demonstrated in (ii), but word definition in (i)   
wrong, allow mark transfer from (ii) to (i)

(c) (i) *Ka* =  **(1)** 1

do **not** expression allow with [H2O]; allow [H3O+]

allow consequential mark from wrong equation in (b) providing  
[H+] present

(ii) *Ka* =  or [H+] =  **(1)**

[H+] = 

= 0.0053 **(1)**

pH = 2.3 / 2.28 **(1)** 3

allow mark for correct pH from wrong [H+]

(d) hydrogen fluoride **or** HF **(1)**

donates a proton (to the nitric acid) **(1)**

conjugate base F– (this mark dependent on correct identification of acid) **(1)** 3

[11]

**29.** (a) (i) proton donor **(1)** 1

(ii) partially dissociated (into ions) (**not** weakly dissociated) **(1)** 1

(b) (i) *Ka* =  **(1)** 1

allow either [H3O+] or [H+] in expression  
must include charges  
if [H2O] included then no mark

(ii) p*Ka* = –log(l.7 × 10–5) **=** 4.77 / 4.8/4.80 **(1)** 1

(c) (i) indicator: phenolphthalein **(1)**

explanation: weak acid-strong base / pH change above 7.0 **(1)**

link between pH change and indicator range **(1)** 3

(ii) colourless to red / pink / purple **(1)** 1

if methyl orange named as indicator - wrong but allow second explanation  
mark and colour change mark in (ii) (ie pink / red  yellow / orange)

(iii) NaOH + CH3COOH  CH3COONa + H2O **(1)**

if charges shown they must be correct  
accept H+ + OH–  H2O 1

(d) excess acid + NaOH / acid + NaOH = NaEt **(1)**

in 2:1 ratio of volumes / 2:1 mol / 1:1 acid: salt **(1)** 2

(e) (i) O–H / C=O bonds are polar (words or on diagram)

due to different electronegativities of O and H (or O and C) **(1)**

lone pairs of electrons on O atoms **(1)**

attraction of + H atom in O–H for – O atom / lone pair in C=O  
between different molecules **(1)** Max 3

[14]

**30.** (a) *Weak acid* An acid which only partially ionises **(1)**  
*Example* Ethanoic, carbonic etc **(1)** 2

(b) *Expression* *K*a =  **(1)**   
*Units* mol dm–3 (or mol l–1) **(1)** 2

(c) (i) The dissociation of water is an endothermic process **(1)**  
Less dissociation on cooling (or equilibrium moves to water or  
*K*w decreases) **(1)** less H+ (or[H+] lower) **(1)**

(ii) Because [H+] = [OH-] **(1)** 4

(d) Resists change in pH **(1)** on addition of small quantities of acid or base **(1)** 2

[10]

**31.** (a) (i) Strong = fully dissociated )  
Weak = partially dissociated ) in aqueous solution both needed **(1)** 1

(ii) *K*a   = 2.07 × 10–5  **(1)** mol dm–3 (not M) **(1)** 2

Explanation: HX barely dissociates OR [H+] very small **(1)**  
so [HX]eqm = [HX] original  **(1)**  
and [H+] = [X–] in an aqueous solution of weak acid **(1)** 3

(b) (i) moles H+ in 18 cm3 = 18 × 0.16 × 10–3 = 2.88 × 10–3  **(1)**  
moles OH– in *V* eqv cm3 = 2×  **(1)** (*V*eqv × 0.12 × 10–3)   
 *V*eqv =  = 12.0 cm3  **(1)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Start | Half equivalence | Equivalence | Double equivalence |
| Volume/cm3 Ba(OH)2 solution added | 0.0 | ***6.0*** | ***12.0*** | ***24.0*** |
| pH for titration of **S** | 0.80 | ***1.22*** | 7 | ***12.84*** |
| pH for titration of **W** | 2.74 | ***4.68*** | 8.5 | ***12.84*** |

3

|  |  |  |
| --- | --- | --- |
| (ii) | **Strong acid S** | **Weak acid W** |
| *Half-equivalence*  Volume of base = 6 cm3 | 9 cm3 of strong acid **S**  **(1)** in (18 + 6) cm3 = 24 cm3  **(1)** [H+] = 9 × 0.16/24 = 0.06 M  **(1)**  pH = 1.22  **(1)** | [HX] = [X–] (given)  pH = pKa or [H+] = *K*a  **(1)**  = – log (2.07 × 10–5)  = 4.68  **(1)** |
| *2 × equivalence*  Volume of base = 24 cm3 | 12 cm3 of base **B** in excess  **(1)** in (18 + 24) cm3 = 42 cm3  **(1)**  [OH–] = 12 × 2 × 0.12/42  = 0.069 M  **(1)**  [H+]= *K*w/[OH–]  **(1)**  = 1.46 × 10–13 M  **(1)**  pH = 12.84  **(1)** | Same as for strong acid **S**  pH = 12.84  **(1)** |

[13 Max]

10

(iii) *Graph*: Sensibly scaled volume axis  **(1)**  
 4 points in text correctly plotted (–1 for each error) **(2)**  
 vertical portion at equivalence on graph for **S**  **(1)**  
 single high pH curve for both **S** and **W**  **(1)**  
 Weak acid (**W**) has marked pH rise at start **(1)**



5

(c) (i) *Buffer Properties* resists change in pH  **(1)**  
 on adding small amounts of acid or base  **(1)**

**W** *as a Buffer* Plenty of X– present to mop up H+  **(1)**  
 Plenty of HX present to mop up OH–  **(1)**  
 OR equations showing same  
 e.g. H+ + X–  HX, OH– + HX  X– + H2O

(ii) *acid buffers* act at low pH, *basic buffers* act at high pH  **(1)**  
half–neutralised **W** is an *acid buffer*  **(1)**  
*basic buffer*: mix weak base with the salt of its co–acid  **(1)**  
OR correct specific example 6

[30]

**32.** (a) pH = –log[H+] 1

 1

[H+]= 1.74 × 10–5 × 0.15 (or 1.62 × 10–3) 1

pH = 2.79 (penalise 1 dp or more than 2dp once in the qu) 1

(b) (i) Solution which resists change in pH /maintains pH 1  
despite the addition of (small amounts of) acid/base (or dilution) 1

(ii) CH3COO + H+ CH3COOH 1  
must show an equation full or ionic in which ethanoate ions are  
converted to ethanoic acid

(c) (i)  if rearrangement incorrect, no further marks 1

 1

(= 2.61 × 10–5 )

pH = 4.58 1

(ii) Ml moles H+ added = 10 × 10–3 × 1.0 = 0.01 1  
M2 moles ethanoic acid after addition = 0.15 + 0.01 = 0.16 1  
M3 moles ethanoate ions after addition = 0.10 -0.01 = 0.09 1

M4  1

( = 3.09 ×10–5)

M5 pH = 4.51 1

The essential part of this calculation is addition/subtraction of 0.01 moles to gain marks   
M2 and M3. If both of these are missing, only mark Ml is available. Thereafter treat each   
mark independently, except if the expression in M4 is wrong, in which case both   
M4 and M5 are lost.

[15]

*alternative scheme for part (c)(i)*

 1

pKa = 4.76 1

 1

*alternative for penultimate mark of part (c)(ii)*

 1

Recommended Resources

The following is a list of resources that you will find helpful during your summer work. This list is by no means exhaustive. Please feel free to share other resources with each other.

1. Kerboodle AQA Chemistry A-Level Textbook - [www.kerboodle.com](http://www.kerboodle.com)

2. CGP revision guides.

3. Allery Chemistry Youtube channel - https://www.youtube.com/channel/UCPtWS4fCi25YHw5SPGdPz0g

Final Words

Year 13 A-Level Chemistry is not simply a progression of Year 12. It is a step-up. **You must step-up your attitude and work ethic.**

A-Level Chemistry is one of the most challenging A-Levels anyone can undertake. As such, A-Level Chemistry is one of the most rewarding  
A-Levels anyone can undertake.

If you are carrying on your A-Level Chemistry into Year 13, it is because you have been allowed to do so by your teachers, who feel you are worthy of the challenge. If you are carrying on your A-Level Chemistry into Year 13, you have been given the opportunity to achieve something you will cherish for a life-time to come.

Work hard.  
  
Look forward to all the amazing things you have yet to learn about.

Look forward to achieving something truly remarkable.  
  
Enjoy your summer holidays!