**ACIDS AND BASES A-LEVEL WORKSHOP ANSWERS**

**1.** (i) an acid is a proton / H+ donor

(ii) HNO2 + H2O→ NO2- + H3O+

(iii) sulfuric acid is behaving as the acid / nitric acid is behaving as a base as it donates a proton / as it accepts a proton

**2.** (a) Increase rate of reaction

(b) MgCO3 + 2HCl → MgCl2 + CO2 + H2O

**3.** NH4+ (acid) and NH3 (base); H2O (acid) and OH− (base)

**4.** Kw = [H+][OH–]

**5**. pH = 2.7

**6.** pH between 2 and 6.5; NH4+ + H2O⇌ NH3 + H3O+

**7**(f) pH = 1.7 [NOTE: this is the A-level answer and is incorrect]

**8.** (i) $K\_{a}= \frac{\left[HCOO^{-}\right]\_{eq}\left[H^{+}\right]\_{eq}}{\left[HCOOH\right]\_{eq}}$

(ii) pH = 2.22

(iii) A buffer is a solution that is made up of approximately equal proportions (within about 5:1) of a weak conjugate acid/base pair. It keeps the pH almost constant when small amounts of acid or base are added.

Adding acid shifts the equilibrium to the left which removes H+ / Adding base removes H+ shifts equilibrium to right which replaces H+

**9.**(a) (i) An acceptor of hydrogen ions / H+(aq)

(ii) He overshot the endpoint / the burette was not rinsed out with the acid solution / some water remained in the burette

(iii) Mean volume of iodic(V) acid = 18.60 cm3. [iodic(V) acid] = 0.168 (mol dm-3)

**10.** (i) 26.20 cm3

ii) 0.38 %

(iii) Some possible reasons:

* funnel kept in burette, therefore value of titre less, since more acid dropped into burette from funnel
* difficult to see when indicator changed colour, therefore value of titre more, since end point overshot
* jet not filled / air bubble in burette, therefore value of titre more, since acid used to fill jet / bubble
* burette not rinsed with acid beforehand, therefore value of titre is more, since acid solution is more dilute

**11.** (a) no more effervescence

* use larger beaker / conical flask - prevents acid spray from escaping
* rinse beaker and add washings to flask - ensures no acid left in beaker
* use more acid / less chalk - gives larger titres therefore smaller percentage error
* crush the chalk / heat the solution / stir the solution - speeds up the reaction

(c) 95.3 %

**12**a) A weak acid is one that partially dissociates (in aqueous solution). A dilute acid is one where a small amount of acid has been dissolved in a large volume of water

(b) Curve A is 0.1 mol dm-3 HCl. Only acid with pH of 1 / curve starts at 1 / strong acid since centre of vertical region is around pH 7

(ii) 0.1 mol dm-3 CH3COOH. Weak acid since vertical region of curve is between 6 and 10 / centre of vertical region is around pH 8 / part of curve shows buffering effect. pH is about 3 at start so concentration cannot be 0.001

(iii)  Thymol blue - pH range coincides with pH change during sharp rise in curve B

(iv)   0.083mol dm-3.

(c) NH4+ + H2O⇌ NH3 + H3O+

**13a**. species that accepts H+ / releases OH‒ in a reversible reaction

b. buffer maintains a constant pH upon addition of small amounts of acid or base

NH3 + H2O⇌ NH4+ + OH−

NH4Cl dissociates to produce NH4+ so both ammonium and ammonia are present

Addition of addition of OH‒ shifts equilibrium to left

Addition of H+ reacts with OH‒ which shifts equilibrium to right

ci. about 9.3

ii 4-nitrophenol as pH range lies on the steep / vertical part of the curve

**14.** (b)

1. Oxalic acid has two acidic protons

2. The Ka/acidity/ease of removal of each proton is different so they give two different vertical regions

3. First vertical region occurs at half the volume of second as each occurs after removing same number of protons

4. Flat regions from 5-10 and 20-25 due to formation of buffer

5. Alice, Brychan and David methods will work

6. Indicators only work if they change colour within a vertical region

7. Alice’s method allows the first and second equivalence points to be found by plotting a curve

8. Brychan’s indicator will change colour fully during the second vertical region

9. David’s indicator will change colour fully during the first vertical region

10. Carys’s method will not work as indicator will change colour gradually as sodium hydroxide is added

**15**a) Kw = [H+][OH‒] Units = mol2dm-6

(b)

(i) In pure water [H+] = [OH‒] or [H+] = √1.0 × 10‒14

pH = ‒log 10‒7 = 7

(ii) pH = 3

(c) pH = 5.05

(d) The solution is a buffer. Solution contains a large amount of CH3COOH and CH3COO‒

ions. When an acid is added, the CH3COO‒ ions react with the H+ ions, removing them from solution and keeping the pH constant

**16.** (b) strong acid is one that fully dissociates in aqueous solution

concentrated acid consists of a large quantity of acid and a small quantity of water

(c) 7.95 × 10‒3 mol dm‒3

(ii) If pH = 2.10 then [H+] = 7.94 × 10‒3 mol dm‒3

Thus acid fully dissociated (and teacher is correct)

**17. i.** $K\_{a}= \frac{\left[F^{-}\right]\_{eq}\left[H^{+}\right]\_{eq}}{\left[HF\right]\_{eq}}$

(ii) pH = 2.07 [NOTE: this is the A-level answer and is incorrect]

(iii) select an indicator whose colour change is complete in the vertical region (equivalent point). As HF is a good weak acid, the conjugate base will be a very weak one so the pH at the equivalence point will be between 8 and 10.

(iv)(I) HF ⇌ H+ + F‒ / reversible reaction (or equilibrium); addition of a small amount of acid reacts with fluoride ions / shifts equilibrium to left; addition of OH‒ reacts with acid so shifts to right.

(II) pH = 3.14