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CHEMISTRY

Edexcel AS & A LEVEL

Topic Questions

Paper 1: Advanced Inorganic and Physical Chemistry

1 The dihydrogenphosphate-hydrogenphosphate ion system is an important buffer in the human body.

$$H_2PO_4^- + H_2O \rightleftharpoons HPO_4^{2-} + H_3O^+$$

(a) In this system, there are two acid-base conjugate pairs. These are

(1)

		acid with its conjugate base	base with its conjugate acid
☒	**A**	$H_2PO_4^-$ / HPO_4^{2-}	H_2O / H_3O^+
☒	**B**	H_2O / H_3O^+	HPO_4^{2-} / $H_2PO_4^-$
☒	**C**	H_3O^+ / H_2O	$_2PO_4^-$ / HPO_4^{2-}
☒	**D**	$H_2PO_4^-$ / HPO_4^{2-}	H_3O^+ / H_2O

(b) A formula that can be used for the calculation of the pH of this buffer solution is

$$pH = pK_a + \log\left(\frac{[HPO_4^{2-}]}{[H_2PO_4^-]}\right)$$

Calculate the pH of this buffer using

$pK_a = 7.20$ $[HPO_4^{2-}] = 3.98 \times 10^{-8}$ mol dm^{-3} $[H_2PO_4^-] = 3.89 \times 10^{-7}$ mol dm^{-3}

(1)

☒ **A** 6.19

☒ **B** 6.21

☒ **C** 7.20

☒ **D** 8.19

(Total for Question = 2 marks)

2 Calculate the pH of a solution of HCl, of concentration 0.25 mol dm^{-3}.

☒ **A** –0.60

☒ **B** 0.25

☒ **C** 0.60

☒ **D** 1.39

(Total for Question = 1 mark)

3 Select the correct pH for each of the following solutions.

(a) 2 mol dm^{-3} nitric acid.

(1)

☒ **A** −2

☒ **B** −0.3

☒ **C** +0.3

☒ **D** +2

(b) 0.10 mol dm^{-3} barium hydroxide, $Ba(OH)_2$. $K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6}.

(1)

☒ **A** 13.0

☒ **B** 13.3

☒ **C** 13.7

☒ **D** 14.3

(c) A mixture of 20 cm^3 of 1.0 mol dm^{-3} hydrochloric acid and 10 cm^3 of 1.0 mol dm^{-3} sodium hydroxide.

(1)

☒ **A** 0

☒ **B** 0.30

☒ **C** 0.48

☒ **D** 7

(Total for Question = 3 marks)

4 Ammonia reacts with water in a reversible reaction. Which are the Brønsted-Lowry bases?

☒ **A** H_2O and OH^-

☒ **B** NH_3 and OH^-

☒ **C** NH_4^+ and H_2O

☒ **D** NH_4^+ and NH_3

(Total for Question = 1 mark)

5 Suggest the most likely pH for each of the following solutions.

(a) 5.0 mol dm^{-3} hydrochloric acid.

(1)

☒ **A** +5

☒ **B** +0.7

☒ **C** –0.7

☒ **D** –5

(b) 0. mol dm^{-3} strontium hydroxide, $Sr(OH)_2$

$K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6}

(1)

☒ **A** 13.3

☒ **B** 13.6

☒ **C** 14.0

☒ **D** 14.3

(c) A mixture of 20 cm^3 of 1.0 mol dm^{-3} nitric acid and 10 cm^3 of 1.0 mol dm^{-3} sodium hydroxide.

(1)

☒ **A** 0

☒ **B** 0.30

☒ **C** 0.48

☒ **D** 7

(Total for Question = 3 marks)

6 In liquid ammonia the following equilibrium is present.

$$NH_2^- + NH_4^+ \rightleftharpoons 2NH_3$$

Identify the Brønsted-Lowry base(s).

☒ **A** NH_2^- only

☒ **B** NH_4^+ only

☒ **C** NH_2^- and NH_3

☒ **D** NH_4^+ and NH_3

(Total for Question = 1 mark)

7 A solution of potassium manganate(VII) was used to determine the concentration of iron(II) ions in solution by titration in the presence of excess dilute sulfuric acid.

(a) With the potassium manganate(VII) in the burette, the end-point of the reaction is when the solution in the conical flask turns

(1)

☒ **A** colourless.

☒ **B** pink.

☒ **C** green.

☒ **D** orange.

(b) If insufficient acid is added, the titre value is

(1)

☒ **A** low and a brown precipitate forms.

☒ **B** low and a green precipitate forms.

☒ **C** high and a brown precipitate forms.

☒ **D** high and a green precipitate forms.

(Total for Question = 2 marks)

8 Separate 0.1 mol dm^{-3} aqueous solutions of ammonia, methylamine and phenylamine were prepared. Which of the following sequences shows the solutions in order of **increasing** pH?

☒ **A** phenylamine, methylamine, ammonia

☒ **B** phenylamine, ammonia, methylamine

☒ **C** methylamine, ammonia, phenylamine

☒ **D** methylamine, phenylamine, ammonia

(Total for Question = 1 mark)

9 The dissociation constant of water, K_w, increases with increasing temperature. When the temperature increases, water

- ☒ **A** remains neutral.
- ☒ **B** dissociates less.
- ☒ **C** becomes acidic.
- ☒ **D** becomes alkaline.

(Total for Question = 1 mark)

10 The reaction between concentrated sulfuric acid and pure ethanoic acid is

$$CH_3COOH + H_2SO_4 \rightleftharpoons CH_3COOH_2^+ + HSO_4^-$$

The Brønsted-Lowry acids in this equilibrium are

- ☒ **A** CH_3COOH and H_2SO_4
- ☒ **B** $CH_3COOH_2^+$ and HSO_4^-
- ☒ **C** H_2SO_4 and $CH_3COOH_2^+$
- ☒ **D** CH_3COOH and HSO_4^-

(Total for Question = 1 mark)

11 An aqueous solution of ethanoic acid is gradually diluted. Which of the following statements is **incorrect**?

- ☒ **A** The pH decreases.
- ☒ **B** The value of K_a is unchanged.
- ☒ **C** The concentration of ethanoic acid molecules decreases.
- ☒ **D** The proportion of ethanoic acid molecules which dissociates increases.

(Total for Question = 1 mark)

12 Methyl orange and phenolphthalein are both acid-base indicators. In the titration of a strong acid against a weak alkali

☒ **A** methyl orange is a suitable indicator but phenolphthalein is not.

☒ **B** phenolphthalein is a suitable indicator but methyl orange is not.

☒ **C** both phenolphthalein and methyl orange are suitable indicators.

☒ **D** neither phenolphthalein nor methyl orange is a suitable indicator.

(Total for Question = 1 mark)

13 Which of the following statements is true about **all** substances that form acidic solutions in water?

☒ **A** They are corrosive.

☒ **B** They are liquids.

☒ **C** They contain hydrogen atoms.

☒ **D** They form $H^+(aq)$ ions.

(Total for Question = 1 mark)

14 Select the correct pH for each of the following solutions.

(a) Nitric acid, HNO_3, of concentration 2 mol dm^{-3}, assuming it is fully dissociated.

(1)

☒ **A** –0.3

☒ **B** 0.0

☒ **C** 0.3

☒ **D** 2.0

(b) Sodium hydroxide, NaOH, of concentration 2 mol dm^{-3}, using $K_w = 1.0 \times 10^{-14}$ mol^2 dm^{-6}

(1)

☒ **A** –13.7

☒ **B** 13.7

☒ **C** 14.0

☒ **D** 14.3

(c) Ethanoic acid, CH_3COOH, of concentration 2 mol dm^{-3}, making the usual assumptions.

$$K_a = \frac{[H^+][CH_3COO^-]}{[CH_3COOH]} = 1.7 \times 10^{-5} \text{ mol dm}^{-3}$$

(1)

☒ **A** 2.2

☒ **B** 2.4

☒ **C** 4.5

☒ **D** 4.8

(d) The mixture formed when 25 cm^3 of 2 mol dm^{-3} sodium hydroxide solution is added to 50 cm^3 of 2 mol dm^{-3} ethanoic acid, for which $K_a = 1.7 \times 10^{-5}$ mol dm^{-3}.

(1)

☒ **A** 2.2

☒ **B** 2.5

☒ **C** 4.5

☒ **D** 4.8

(Total for Question = 4 marks)

15 In which of these reactions is the hydrogensulfate ion, HSO_4^-, behaving as a Brønsted-Lowry base?

☒ **A** $HSO_4^- + H_3O^+ \rightarrow H_2SO_4 + H_2O$

☒ **B** $HSO_4^- + Ba^{2+} \rightarrow BaSO_4 + H^+$

☒ **C** $HSO_4^- + H_2O \rightarrow SO_4^{2-} + H_3O^+$

☒ **D** $HSO_4^- + CO_3^{2-} \rightarrow SO_4^{2-} + HCO_3^-$

(Total for Question 1 mark)

16 A solution of hydrochloric acid has pH 3.0. When it is made 10 times more dilute, the pH is

☒ **A** 0.3

☒ **B** 2.0

☒ **C** 4.0

☒ **D** 13.0

(Total for Question 1 mark)

17 In which reaction is water acting as a Brønsted-Lowry acid?

☒ **A** $H_2O + HCl \rightarrow H_3O^+ + Cl^-$

☒ **B** $H_2O + SO_3 \rightarrow H_2SO_4$

☒ **C** $H_2O + NH_3 \rightarrow NH_4^+ + OH^-$

☒ **D** $H_2O + CO_2 \rightarrow H_2CO_3$

(Total for Question = 1 mark)

18 Which of the following solutions has the lowest pH?

☒ **A** 0.010 mol dm^{-3} hydrochloric acid.

☒ **B** 0.100 mol dm^{-3} hydrochloric acid.

☒ **C** 0.010 mol dm^{-3} ethanoic acid.

☒ **D** 0.100 mol dm^{-3} ethanoic acid.

(Total for Question = 1 mark)

19 An aqueous solution of ammonium chloride, NH_4Cl, has a pH of less than 7 because

☒ **A** the ammonium ions donate protons to water molecules giving rise to oxonium ions, $H_3O^+(aq)$.

☒ **B** the chloride ions combine with hydrogen ions from water to form hydrochloric acid, HCl(aq).

☒ **C** an aqueous solution of ammonium chloride is unstable and evolves ammonia gas, $NH_3(g)$, leaving dilute hydrochloric acid.

☒ **D** the ammonium chloride reacts with carbon dioxide from the atmosphere giving ammonium carbonate, $(NH_4)_2CO_3(aq)$, and hydrochloric acid, HCl(aq).

(Total for Question = 1 mark)

20 Which one of the following indicators is most suitable for titrating ethanoic acid with 0.1 mol dm^{-3} sodium hydroxide?

(Refer to page 19 of your data booklet.)

☒ **A** Thymol blue (acid)

☒ **B** Bromothymol blue

☒ **C** Thymol blue (base)

☒ **D** Alizarin yellow R

(Total for Question = 1 mark)

21 What is the conjugate base of the acid, HCO_3^-?

- ☒ **A** H_2CO_3
- ☒ **B** CO_3^{2-}
- ☒ **C** OH^-
- ☒ **D** CO_2

(Total for Question = 1 mark)

22 The pH of a 1.5 mol dm ^{3} solution of hydrochloric acid, HCl(aq), is

- ☒ **A** 1.50
- ☒ **B** 0.18
- ☒ **C** 0.18
- ☒ **D** 1.50

(Total for Question 1 mark)

23 Which sequence shows the bases in order of decreasing strength?

- ☒ **A** $C_6H_5NH_2 > CH_3NH_2 > NH_3$
- ☒ **B** $NH_3 > CH_3NH_2 > C_6H_5NH_2$
- ☒ **C** $CH_3NH_2 > NH_3 > C_6H_5NH_2$
- ☒ **D** $NH_3 > C_6H_5NH_2 > CH_3NH_2$

(Total for Question 1 mark)

24 Which of the following is **not** a reaction of a Brønsted-Lowry acid and base?

☒ **A** $CH_3Cl + OH \rightarrow CH_3OH + Cl$

☒ **B** $NH_3 + HCl \rightarrow NH_4^+ + Cl$

☒ **C** $H_2O + HSO_4 \rightarrow H_2SO_4 + OH$

☒ **D** $HCO_3 + H_2O \rightarrow CO_3^{2} + H_3O^+$

(Total for Question 1 mark)

25 Information about four samples of acid is shown below.

Sample 1: 1.0 mol dm ^{3} HCl

Sample 2: 1.0 mol dm ^{3} H_2SO_4

Sample 3: 0.1 mol dm ^{3} HCl

Sample 4: 0.1 mol dm ^{3} CH_3COOH

Which of the following lists shows the samples in order of increasing pH?

☒ **A** 1, 2, 3, 4

☒ **B** 4, 3, 2, 1

☒ **C** 2, 1, 3, 4

☒ **D** 4, 3, 1, 2

(Total for Question 1 mark)

26 In which of the following reactions is nitric acid acting as a base?

☒ **A** $HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

☒ **B** $HNO_3 + H_2O \rightarrow H_3O^+ + NO_3^-$

☒ **C** $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$

☒ **D** $HNO_3 + NaHCO_3 \rightarrow NaNO_3 + H_2O + CO_2$

(Total for Question = 1 mark)

27 The dissociation of ethanoic acid in aqueous solution is represented by

$$CH_3COOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CH_3COO^-(aq)$$

Which of the following statements is true for this equilibrium?

☒ **A** CH_3COOH is an acid and its conjugate base is CH_3COO^-.

☒ **B** H_2O is an acid and its conjugate base is OH^-.

☒ **C** At equilibrium, the concentrations of each substance are the same.

☒ **D** At equilibrium, the reaction from left to right and the reaction from right to left have stopped.

(Total for Question = 1 mark)

28 Why are aqueous solutions of sodium ethanoate slightly alkaline?

☒ **A** The sodium ions react with water to give an alkali.

☒ **B** The ethanoate ions react with water to give hydroxide ions.

☒ **C** All sodium salts give alkaline solutions.

☒ **D** The sodium ethanoate is fully ionized in solution.

(Total for Question = 1 mark)

29 A solution of a weak acid cannot be titrated with a weak base using an indicator to find the end-point because

☒ **A** the pH change is too gradual close to the equivalence point.

☒ **B** there are too few H^+ ions to affect the indicator.

☒ **C** there are too few OH^- ions to affect the indicator.

☒ **D** the pH change occurs outside the range of any indicator.

(Total for Question = 1 mark)

30 At 100 °C, pure water has a pH of 6, whereas at 25 °C it has a pH of 7. This is because

☒ **A** the dissociation of water is endothermic, so the concentration of hydrogen ions is lower at 100 °C than it is at 25 °C.

☒ **B** the dissociation of water is exothermic, so the concentration of hydrogen ions is lower at 100 °C than it is at 25 °C.

☒ **C** the dissociation of water is endothermic, so the concentration of hydrogen ions is higher at 100 °C than it is at 25 °C.

☒ **D** at 100 °C, water has a higher concentration of hydrogen ions than of hydroxide ions.

(Total for Question = 1 mark)