95. Which of the following describes the net ionic reaction for the hydrolysis of $NH_4Cl_{(s)}$?

A. $NH_4{}^+{}_{(aq)} + Cl^-{}_{(aq)} \rightleftarrows NH_4Cl_{(s)}$

B. $NH_4Cl_{(s)} \rightleftarrows NH_4{}^+{}_{(aq)} + Cl^-{}_{(aq)}$

C. $Cl^-{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows HCl_{(aq)} + OH^-{}_{(aq)}$

D. $NH_4{}^+{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)}$

96. Which of the following salts will produce a solution with the highest pH?

A. 1.0 M $NaNO_3$
B. 1.0 M $NaHSO_4$
C. 1.0 M $NaHCO_3$
D. 1.0 M NaH_2PO_4

97. *A substance which produces hydroxide ions in solution* is a definition of which of the following?

A. an Arrhenius acid
B. an Arrhenius base
C. a Brønsted-Lowry acid
D. a Brønsted-Lowry base

98. Which of the following is generally true of acids, but **not** for bases?

A. $pH > 7$
B. release H^+ in solution
C. conduct current when in solution
D. cause indicators to change colour

99. Which of the following 1.0 M solutions will have the highest electrical conductivity?

A. HI
B. HF
C. HCN
D. HNO_2

100. Consider the following equilibrium:

$$HOI + F^- \rightleftarrows OI^- + HF$$

Reactants are favoured in this equilibrium. Which of the following describes the relative strengths of the acids and the bases?

	Stronger Acid	Stronger Base
A.	HF	F^-
B.	HF	OI^-
C.	HOI	F^-
D.	HOI	OI^-

101. Which of the following is true for a neutral aqueous solution?

A. $[H_3O^+] = 0.0\,M$
B. $[H_3O^+] = [OH^-]$
C. $[H_3O^+] > [OH^-]$
D. $[H_3O^+] < [OH^-]$

102. Which of the following is a definition of pK_w ?

A. $pK_w = -\log K_w$
B. $pK_w = pH - pOH$
C. $pK_w = 7.0$ at $25°C$
D. $pK_w = [H_3O^+][OH^-]$

103. Consider the following equilibrium:

$$H_2CO_{3(aq)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + HCO_3^-{}_{(aq)}$$

What is the equilibrium expression?

A. $K_a = \dfrac{[H_3O^+][HCO_3^-]}{[H_2CO_3]}$

B. $K_a = \dfrac{[H_2CO_3]}{[H_3O^+][HCO_3^-]}$

C. $K_a = \dfrac{[H_2CO_3][H_2O]}{[H_3O^+][HCO_3^-]}$

D. $K_a = \dfrac{[H_3O^+][HCO_3^-]}{[H_2CO_3][H_2O]}$

104. Which of the following describes the net ionic equation for the hydrolysis of a $NaNO_2$ solution?

A. $NaNO_{2(s)} \rightleftarrows Na^+_{(aq)} + NO_{2\ (aq)}^-$

B. $NO_{2\ (aq)}^- + H_2O_{(\ell)} \rightleftarrows HNO_{2(aq)} + OH^-_{(aq)}$

C. $Na^+_{(aq)} + 2H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + NaOH_{(aq)}$

D. $NaNO_{2(s)} + H_2O_{(\ell)} \rightleftarrows NaOH_{(aq)} + HNO_{2(aq)}$

105. The $HC_2O_{4\ (aq)}^-$ ion will act as

A. a base since $K_a < K_b$
B. a base since $K_a > K_b$
C. an acid since $K_a < K_b$
D. an acid since $K_a > K_b$

106. Which of the following is a property of **all** acidic solutions at $25°C$?

A. They have a pH less than 7.0.
B. They have a pH greater than 7.0.
C. They cause phenolphthalein to turn pink.
D. They release hydrogen when placed on copper metal.

107. When a small solid sample is added to a solution of H_2SO_4, a precipitate forms and the solution becomes less acidic. Which of the following substances could have caused these results?

A. Na_2SO_4
B. $Sr(OH)_2$
C. $Mg(OH)_2$
D. $Ca(NO_3)_2$

108. Consider the following reaction:

$$HCN + CH_3NH_2 \rightleftarrows CN^- + CH_3NH_3^+$$

Which of the following describes a conjugate acid-base pair in the equilibrium above?

	Acid	Base
A.	CN^-	HCN
B.	$CH_3NH_3^+$	CN^-
C.	HCN	$CH_3NH_3^+$
D.	$CH_3NH_3^+$	CH_3NH_2

109. Which of the following is the weakest base?

A. F^-
B. HS^-
C. CN^-
D. IO_3^-

110. Which of the following relationships is used to calculate K_w at $30°C$?

A. $K_w = pH + pOH$
B. $pK_w = -\log[H_3O^+]$
C. $K_w = [H_3O^+][OH^-]$
D. $K_w = [H_3O^+] + [OH^-]$

111. What is the pOH of $0.2\,M\ HNO_3$?

A. 5×10^{-14}
B. 0.2
C. 0.7
D. 13.3

112. Which of the following K_a values represents the acid with the strongest conjugate base?

A. $K_a = 4.2 \times 10^{-12}$
B. $K_a = 9.5 \times 10^{-9}$
C. $K_a = 2.0 \times 10^{-5}$
D. $K_a = 7.8 \times 10^{-3}$

113. What is the dissociation equation for Na_2CO_3 in water?

A. $Na_2CO_{3(s)} \rightarrow Na^{2+}_{(aq)} + CO_3{}^{2-}{}_{(aq)}$
B. $Na_2CO_{3(s)} \rightarrow 2Na^+_{(aq)} + CO_3{}^{2-}{}_{(aq)}$
C. $CO_3{}^{2-}{}_{(aq)} + H_2O_{(\ell)} \rightarrow HCO_3{}^-{}_{(aq)} + OH^-_{(aq)}$
D. $Na_2CO_{3(s)} + 2H_2O_{(\ell)} \rightarrow 2NaOH_{(aq)} + H_2CO_{3(aq)}$

114. Which of the following solutions has the highest pH ?

A. $0.1\,M\ HCl$
B. $0.1\,M\ NaF$
C. $0.1\,M\ NaHS$
D. $0.1\,M\ NH_4Cl$

WRITTEN PROBLEMS

1. Consider the following Brønsted-Lowry equilibrium:

$$H_2SO_{3(aq)} + HPO_4{}^{2-}{}_{(aq)} \rightleftarrows H_2PO_4{}^{-}{}_{(aq)} + HSO_3{}^{-}{}_{(aq)}$$

a) Identify the two Brønsted-Lowry acids in the above equilibrium.

b) Define the term *conjugate acid.*

2. Consider the following equilibrium:

$$\text{energy} + 2H_2O \rightleftarrows H_3O^+ + OH^-$$

a) Explain how pure water can have a $pH = 7.30$.

b) Calculate the value of K_w for the sample of water with a $pH = 7.30$.

3. a) Write the equation for the predominant reaction of $HC_2O_4{}^-$ with $HSO_3{}^-$.

$$\underset{\text{acid}}{HC_2O_4{}^-} + \underset{\text{base}}{HSO_3{}^-} \rightleftarrows \_\_\_\_\_\_\_\_\_\_ + \_\_\_\_\_\_\_\_\_\_$$

b) Identify a Brønsted-Lowry conjugate acid base pair from the above reaction.

Acid: ______________________ Base: ______________________

4. Calculate the $\left[OH^-\right]$ in $0.50\,M\ NH_{3(aq)}$.

5. Write the equation for the predominant reaction between $HSO_4{}^-$ and $H_2PO_4{}^-$.

6. A $0.20\,M$ solution of a weak acid, HA, has a $pH = 1.32$.
Use calculations and the table of "Relative Strengths of Brønsted-Lowry Acids and Bases" from the *Data Booklet* to determine the identity of the acid.

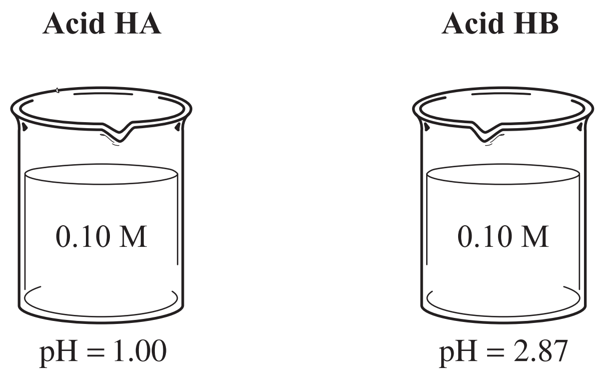
7. Calculate the pH of a solution prepared by mixing $15.0\,mL$ of $0.50\,M$ HCl with $35.0\,mL$ of $1.0\,M$ NaOH.

8. Consider a $1.0\,M$ solution of NH_4F.

a) Write both hydrolysis reactions that occur when NH_4F is dissolved in water.

b) Will the above NH_4F solution be acidic, basic, or neutral?
Support your answer with calculations.

9. Consider the 0.10 M solutions of the following two acids:



a) What can you conclude about the acids that will explain these different pH values?

b) Compare the volume of 0.10 M NaOH needed to neutralize equal volumes of each of these acid samples.

10. Will $HC_2O_4^-$ act predominantly as an acid or as a base in solution? Support your answer with calculations.

11. The two reactants in an acid-base reaction are $HNO_{2(aq)}$ and $HCO_3^-{}_{(aq)}$.

a) Write the equation for the above reaction.
b) Define the term *conjugate acid-base pair*.
c) Write the formulas for a conjugate acid-base pair for the above reaction.

12. At 10.0°C, $K_w = 2.95 \times 10^{-15}$ for pure water.

a) Calculate the pH of water at 10.0°C.

13. At a particular temperature a 1.0 M H_2S solution has a pH = 3.75. Calculate the value of K_a at this temperature.

14. The ion $H_2PO_4^-$ is an amphiprotic anion.

a) Define the term *amphiprotic*.

b) Write the balanced equation for the reaction when $H_2PO_4^-$ reacts with HF.

15. Write an equation for a reaction in which H_2O acts only as a Brønsted-Lowry base.

16. Calculate the pH of 0.25 M $Sr(OH)_2$.

17. Calculate the pH of 0.25 M NH_4Cl.

18. The cyanide ion, CN^-, is a Brønsted-Lowry base.

a) Define *Brønsted-Lowry base*.

b) Write the equation representing the reaction of CN^- with water.

c) Identify a conjugate pair in b) above.

19. Write an equation to show the ionization of water.

20. Calculate the pH of $1.50\,M\ NH_3$.

21. Consider the following equilibria:

I.	$CH_3COOH + OCN^- \rightleftarrows HOCN + CH_3COO^-$
II.	$CH_3COOH + ClO^- \rightleftarrows HClO + CH_3COO^-$

a) In equation **I** above, the reactants are favoured. Identify the stronger acid.

b) In equation **II** above, the products are favoured. Identify the stronger acid.

c) Consider the following reaction:

$$HOCN + ClO^- \rightleftarrows OCN^- + HClO$$

Does this reaction favour reactants or products? Explain.

22. At 60°C, the pH = 6.51 for pure water. Determine the value of K_w at this temperature.

23. Calculate the pH of $0.35\,M\ H_2CO_3$.

24. Write a chemical reaction showing an amphiprotic anion reacting as a base in water.

25. An acid-base reaction occurs between HSO_3^- and IO_3^- .

a) Write the equation for the equilibrium that results.

b) Identify one conjugate acid-base pair in the reaction.

c) State whether reactants or products are favoured, and explain how you arrived at your answer.

26. At 10°C, $K_w = 2.95 \times 10^{-15}$.

a) Determine the pH of water at 10°C.

b) State whether water at this temperature is acidic, basic or neutral, and explain.

27. Calculate the pH of 0.50 M H_2S.

28. a) Write an equation to represent the predominant reaction when $HC_2O_4^-$ is mixed with HSO_4^- .

b) Justify your statement by comparing K_a values.

c) Identify a conjugate acid-base pair.

d) Predict whether the equilibrium will favour the formation of reactants or products. Explain.

29. Write an equation representing the ionization of water and state both ion concentrations that exist for pure water to have a $pH = 7.20$.

30. Calculate the pH of 0.25 M $NaHCO_3$, a basic salt.

31. Write the net ionic equation for the acid-base reaction that occurs between $NaCN_{(aq)}$ and $NH_4Cl_{(aq)}$.

32. Define the term *amphiprotic* and give an example of an amphiprotic anion.

33. At 20°C, the ionization constant of water (K_w) is 6.76×10^{-15} . Calculate the $\left[H_3O^+\right]$ of water at 20°C.

34. Calculate the pH of 0.50 M NaF.

MULTIPLE - CHOICE ANSWERS

1	C	6	C	11	C	16	B	21	D	26	C	31	B	36	D	41	D	46	C
2	C	7	B	12	C	17	A	22	D	27	B	32	B	37	A	42	A	47	D
3	A	8	D	13	B	18	B	23	B	28	C	33	B	38	B	43	B	48	C
4	A	9	C	14	A	19	A	24	A	29	A	34	D	39	A	44	B	49	B
5	B	10	B	15	A	20	C	25	C	30	C	35	B	40	C	45	B	50	C

51	C	56	B	61	B	66	D	71	C	76	B	81	B	86	A	91	C	96	C
52	C	57	D	62	C	67	D	72	C	77	B	82	D	87	B	92	D	97	B
53	C	58	B	63	B	68	A	73	A	78	A	83	C	88	B	93	C	98	B
54	B	59	D	64	A	69	B	74	C	79	C	84	A	89	C	94	A	99	A
55	D	60	B	65	A	70	D	75	B	80	B	85	A	90	C	95	D	100	B

101	B	106	A	111	D														
102	A	107	B	112	A														
103	A	108	D	113	B														
104	B	109	D	114	C														
105	D	110	C																

WRITTEN ANSWERS

1. a) ***For Example:***

Species 1: H_2SO_3 ← **½ mark**

Species 2: $H_2PO_4^-$ ← **½ mark**

b) ***For Example:***

A conjugate acid is a species produced when a proton is accepted by a Brønsted-Lowry base. } ← **1 mark**

2. a) A lower temperature causes a shift to the left.
The $[H_3O^+]$ drops as a result, and the pH increases. } ← **2 marks**

b)

$$[H_3O^+] = [OH^-] = 1 \times 10^{-7.30} = 5.0 \times 10^{-8}\ M$$ ← **1 mark**

$$K_w = [H_3O^+] \times [OH^-] = (5.0 \times 10^{-8})(5.0 \times 10^{-8}) = 2.5 \times 10^{-15}$$ ← **1 mark**

3. a) $HC_2O_4^- + HSO_3^- \rightleftarrows \underline{C_2O_4^{2-}} + \underline{H_2SO_3}$ } ← **1 mark**

base acid

b) $HC_2O_4^- \ / \ C_2O_4^{2-}$

acid base

OR } ← **1 mark**

$HSO_3^- \ / \ H_2SO_3$

base acid

4. $$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$ ← **1 mark**

	NH_3	+	H_2O	$\rightleftarrows$	NH_4^+	+	OH^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

} ← **2 marks**

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{(x)(x)}{(0.50 - x)} = 1.79 \times 10^{-5}$$

Use assumption that $0.50 - x \approx 0.50$ or use the quadratic formula.

$$x = [OH^-] = 3.0 \times 10^{-3}\ M$$

} ← **2 marks**

5. $HSO_4^- + H_2PO_4^- \rightleftarrows SO_4^{2-} + H_3PO_4$ ← **2 marks**

6.

$$pH = 1.32$$
$$[H_3O^+] = 0.048\,M$$
← **1 mark**

	HA	$+$	H_2O	$\rightleftarrows$	H_3O^+	$+$	A^-
[I]	0.20				0		0
[C]	−0.048				+0.048		+0.048
[E]	0.152				0.048		0.048

← **2 marks**

$$K_a = \frac{[H_3O^+][A^-]}{[HA]} = \frac{(0.048)(0.048)}{0.152} = 1.5 \times 10^{-2}$$
← **1 mark**

The acid is: H_2SO_3 ← **1 mark**

7.

moles $HCl = 0.0150\,L \times 0.50\,M = 7.50 \times 10^{-3}$ mol

moles $NaOH = 0.0350\,L \times 1.0\,M = 3.5 \times 10^{-2}$ mol

excess moles $NaOH = 3.5 \times 10^{-2}\text{ mol} - 7.50 \times 10^{-3}\text{ mol} = 2.75 \times 10^{-2}$ mol

$$[NaOH] = [OH^-] = \frac{2.75 \times 10^{-2}\text{ mol}}{0.050\,L} = 0.55\,M$$

$$[H_3O^+] = \frac{1.0 \times 10^{-14}}{0.55} = 1.8 \times 10^{-14}$$

$$pH = 13.74$$

← **4 marks**

8. a) $NH_4{}^+{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows NH_{3(aq)} + H_3O^+{}_{(aq)}$ ← **1 mark**

$F^-{}_{(aq)} + H_2O_{(\ell)} \rightleftarrows HF_{(aq)} + OH^-{}_{(aq)}$ ← **1 mark**

b) K_a for $NH_4{}^+ = 5.6 \times 10^{-10}$

K_b for $F^- = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.9 \times 10^{-11}$

Since $K_a > K_b$, the solution is acidic.

← **2 marks**

9. a) Acid HA is strong.
Acid HB is weak.

b) The same volume of $NaOH_{(aq)}$ is needed for each acid sample.

10. $$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.9 \times 10^{-2}} = 1.7 \times 10^{-13}$$ ← **1½ marks**

Since $K_a = 6.4 \times 10^{-5}$ which is greater than K_b, the ions act as an acid. ← **1½ marks**

11. a) $HNO_{2(aq)} + HCO_3{}^-{}_{(aq)} \rightleftarrows H_2CO_{3(aq)} + NO_2{}^-{}_{(aq)}$ ← **2 marks**

b) A conjugate acid-base pair are two species whose formulas differ by a proton.

HNO_2 and NO_2^- **OR** H_2CO_3 and HCO_3^- c)

12. $$K_w = 2.95 \times 10^{-15} = [H_3O^+][OH^-]$$ ← **1 mark**

Since $[H_3O^+] = [OH^-]$

$$[H_3O^+]^2 = 2.95 \times 10^{-15}$$

$$[H_3O^+] = 5.43 \times 10^{-8}\ M$$ ← **1 mark**

$$pH = 7.265$$ ← **1 mark**

13.

	H_2S	$+ \ H_2O \ \rightleftarrows$	H_3O^+	+	HS^-
[I]	1.0		0		0
[C]	-1.78×10^{-4}		$+1.78 \times 10^{-4}$		$+1.78 \times 10^{-4}$
[E]	$1.0 - 1.78 \times 10^{-4}$		1.78×10^{-4}		1.78×10^{-4}

← **2 marks**

$$pH = 3.75$$

$$[H_3O^+] = 1.78 \times 10^{-4}\ M$$

$$K_a = \frac{[H_3O^+][HS^-]}{[H_2S]} = \frac{(1.78 \times 10^{-4})^2}{1.0 - 1.78 \times 10^{-4}} = 3.2 \times 10^{-8}$$

← **2 marks**

14\. a) Amphiprotic describes the ability to act as an acid in one reaction and as a base in a different reaction. ← **1 mark**

b) $H_2PO_4^- + HF \rightleftarrows H_3PO_4 + F^-$ ← **2 marks**

15\. $HSO_3^- + H_2O \rightleftarrows H_3O^+ + SO_3^{2-}$ ← **2 marks**

16\. $[OH^-] = 0.50\,M$

$pOH = 0.30$

$pH = 13.70$

← **2 marks**

17\.

	NH_4^+	+	H_2O	$\rightleftarrows$	H_3O^+	+	NH_3
[I]	0.25				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.25-x$				x		x

← **2 marks**

$$K_a = 5.6\times10^{-10} = \frac{[H_3O^+][NH_3]}{[NH_4^+]} = \frac{(x)(x)}{0.25-x}$$

$$x = [H_3O^+] = 1.18\times10^{-5}\,M$$

$$pH = 4.93$$

← **3 marks**

18\. a) A Brønsted-Lowry base is a proton acceptor. ← **1 mark**

b) $CN^- + H_2O \rightleftarrows HCN + OH^-$ ← **2 marks**

c) CN^- and HCN **OR** H_2O and OH^- ← **1 mark**

19\. $2H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$ ← **2 marks**

20\.

	NH_3	+	H_2O	$\rightleftarrows$	NH_4^+	+	OH^-
[I]	1.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$1.50-x$				x		x

← **2 marks**

$$K_b = \frac{1.0\times10^{-14}}{5.6\times10^{-10}} = 1.79\times10^{-5}$$

← **1 mark**

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

$$= \frac{x^2}{1.50 - x}$$

$$x = [OH^-] = 5.18 \times 10^{-3}$$

$$pOH = 2.29$$

$$pH = 11.71$$

← **2 marks**

21. a) HOCN ← **1 mark**

b) CH_3COOH ← **1 mark**

c) Products are favoured because HOCN is a stronger acid than HClO. ← **2 marks**

22.

$$pH = 6.51$$

$$[H_3O^+] = 3.09 \times 10^{-7} \text{ M} = [OH^-]$$

$$K_w = [H_3O^+][OH^-] = (3.09 \times 10^{-7})(3.09 \times 10^{-7}) = 9.5 \times 10^{-14}$$

← **3 marks**

23.

	H_2CO_3	+	H_2O	⇄	H_3O^+	+	HCO_3^-
[I]	0.35				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.35 - x$				x		x

← **1½ marks**

$$K_a = \frac{[H_3O^+][HCO_3^-]}{[H_2CO_3]} = 4.3 \times 10^{-7}$$

$$4.3 \times 10^{-7} = \frac{x^2}{0.35 - x}$$

$$x = [H_3O^+] = 3.88 \times 10^{-4} \text{ M}$$

$$pH = 3.41$$

← **2½ marks**

24. $HPO_4^{2-} + H_2O \rightleftarrows H_2PO_4^- + OH^-$ ← **2 marks**

25. a) $HSO_3^- + IO_3^- \rightleftarrows SO_3^{2-} + HIO_3$ ← **1 mark (equilibrium arrow required)**

b) HSO_3^- and SO_3^{2-} **OR** IO_3^- and HIO_3 ← **1 mark**

c) Reactants are favoured. ← **1 mark**

HSO_3^- is a weaker acid than HIO_3 **OR**
IO_3^- is a weaker base than SO_3^{2-} } ← **1 mark**

26. a) $$K_w = 2.95 \times 10^{-15} = [H_3O^+][OH^-]$$ ← **1 mark**

Since $[H_3O^+] = [OH^-]$,

$$[H_3O^+]^2 = 2.95 \times 10^{-15}$$

$$[H_3O^+] = 5.43 \times 10^{-8}$$ ← **1 mark**

$$pH = 7.265$$ ← **1 mark**

b) Since $[H_3O^+] = [OH^-]$, the water is neutral. ← **1 mark**

27.

	H_2S	+	H_2O	$\rightleftarrows$	H_3O^+	+	HS^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

} ← **$1\frac{1}{2}$ mark**

(assume x is negligible)

$$K_a = 9.1 \times 10^{-8} = \frac{[H_3O^+][HS^-]}{[H_2S]} = \frac{(x)(x)}{(0.50)}$$ } ← **1 mark**

$$x = [H_3O^+] = 2.13 \times 10^{-4}$$ ← **1 mark**

$$pH = 3.67$$ ← **$\frac{1}{2}$ mark**

28. a) $HC_2O_4^- + HSO_4^- \rightleftarrows H_2C_2O_4 + SO_4^{2-}$ ← **1 mark**

b) $K_aHSO_4^- > K_aHC_2O_4^-$ ← **1 mark**

c) HSO_4^- and SO_4^{2-}
OR $HC_2O_4^-$ and $H_2C_2O_4$ } ← **1 mark**

d) Reactants are favoured since $K_aHSO_4^- < K_aH_2C_2O_4$ ← **2 marks**

29. $H_2O_{(\ell)} + H_2O_{(\ell)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$ ← **1 mark**

Since pH = 7.20, $[H_3O^+] = 6.3 \times 10^{-8}$ M ← **1 mark**

$[H_3O^+] = [OH^-] = 6.3 \times 10^{-8}$ M ← **1 mark**

30.

	HCO_3^-	+	H_2O	$\rightleftarrows$	H_2CO_3	+	OH^-
[I]	0.25				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.25 - x$				x		x

← **1 mark**

(assume x is negligible)

$$K_b = \frac{1.0 \times 10^{-14}}{4.3 \times 10^{-7}} = \frac{[H_2CO_3][OH^-]}{[HCO_3^-]}$$ ← **1 mark**

$$2.33 \times 10^{-8} = \frac{x^2}{0.25}$$ ← **1 mark**

$$x = [OH^-] = 7.62 \times 10^{-5} \text{ M}$$ ← **1 mark**

$$\text{pOH} = 4.12$$
$$\text{pH} = 9.88$$
← **1 mark**

31. $CN^-_{(aq)} + NH_4{}^+_{(aq)} \rightleftarrows HCN_{(aq)} + NH_{3(aq)}$ ← **2 marks**

32. **Definition:** Amphiprotic describes a substance that can act as either an acid or a base.

Example: HCO_3^-

← **2 marks**

33. $K_w = [H_3O^+][OH^-] = 6.76 \times 10^{-15}$ ← **1 mark**

Since $[H_3O^+] = [OH^-]$, $[H_3O^+]^2 = 6.76 \times 10^{-15}$

$[H_3O^+] = 8.22 \times 10^{-8}$ M ← **1 mark**

34.

	F^-	+	H_2O	$\rightleftarrows$	HF	+	OH^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

← **1 mark**

(assume x is negligible)

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{3.5 \times 10^{-4}} = 2.86 \times 10^{-11} = \frac{[HF][OH^-]}{[F^-]}$$ ← **1 mark**

$$2.86 \times 10^{-11} = \frac{x^2}{0.50}$$ ← **1 mark**

$$x = [OH^-] = 3.78 \times 10^{-6}\ M$$ ← **1 mark**

$$pOH = 5.42$$
$$pH = 8.58$$ ← **1 mark**