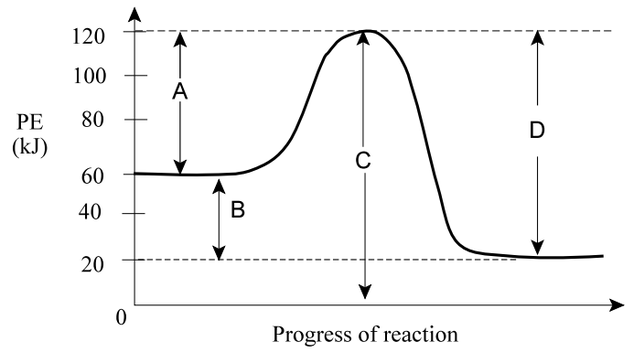
PART I
Total Value: 50%

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.

Use the diagram below to answer the next two questions.



1. Which represents the activation energy for the forward reaction?

✔ (A) A
(B) B
(C) C
(D) D

2. What is ΔH for the forward reaction?

(A) -100 kJ
✔ (B) -40 kJ
(C) 40 kJ
(D) 100 kJ

Refer to the mechanism below to answer the next two questions.

①	$OCl^-(aq) + H_2O(\ell) \rightarrow HOCl(aq) + OH^-(aq)$	*fast*
②	$HOCl(aq) + I^-(aq) \rightarrow HOI(aq) + Cl^-(aq)$	*very slow*
③	$HOI(aq) + OH^-(aq) \rightarrow H_2O(\ell) + OI^-(aq)$	*slow*
④	$Cl^-(aq) + OI^-(aq) \rightarrow ClOI^{2-}$	*very fast*

3. Which species is the catalyst?

✔ (A) $H_2O(\ell)$
(B) HOCl(aq)
(C) HOI(aq)
(D) $OI^-(aq)$

4. Which is the rate determining step?

(A) ①
✔ (B) ②
(C) ③
(D) ④

5. Which term refers to a single step in a reaction mechanism?

✔ (A) elementary
(B) fundamental
(C) intermediate
(D) primary

6. How does a catalyst speed up a chemical reaction?

(A) doubles the concentration of reactants
(B) increases the frequency of collisions
(C) lowers the heat of reaction
✔ (D) provides an alternate pathway

7. Which is necessary for an equilibrium to exist?

(A) closed system and changing temperature
✔ (B) closed system and constant temperature
(C) open system and changing temperature
(D) open system and constant temperature

8. Which change will increase the concentration of $F_2(g)$ in the equilibrium below?

$$2\ HCl(g) + F_2(g) \rightleftarrows 2\ HF(g) + Cl_2(g)\ \Delta H = -74.8\ kJ$$

(A) decrease in pressure
(B) decrease in temperature
(C) increase in pressure
✔ (D) increase in temperature

9. Which change in the equilibrium below would result in the highest concentration of $Cl_2(g)$?

$$PCl_3(g) + Cl_2(g) \rightleftarrows PCl_5(g) \qquad \Delta H = -84.2\ kJ$$

(A) decreasing temperature
(B) decreasing volume
(C) increasing $[PCl_3]$
✔ (D) increasing $[PCl_5]$

10. What is the equilibrium constant expression for the equilibrium below?

$$4\ Al(s) + 3\ O_2(g) \rightleftarrows 2\ Al_2O_3(s)$$

(A) $\dfrac{[Al_2O_3(s)]^2}{[Al(s)]^4[O_2(g)]^3}$

(B) $\dfrac{[Al(s)]^4[O_2(g)]^3}{[Al_2O_3(s)]^2}$

✔ (C) $\dfrac{1}{[O_2(g)]^3}$

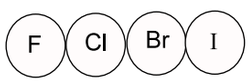
(D) $[O_2(g)]^3$

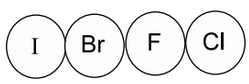
11. Which K value favours the reactants?

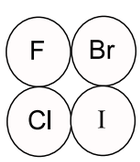
✔ (A) 0.00016
(B) 4.0
(C) 87
(D) 73 000

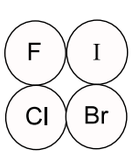
12. For the reaction below, which most likely represents the activated complex in a one-step reaction mechanism?

$$FCl(g) + BrI(g) \rightarrow BrF(g) + ICl(g)$$

(A) 

(B) 

✔ (C) 

(D) 

13. Which is a property of a base?

(A) reacts with metals to produce $H_2(g)$
(B) reacts with nonmetals to produce $O_2(g)$
✔ (C) tastes bitter
(D) tastes sweet

14. Which theory states that acids react with water to produce $H_3O^+(aq)$?

(A) Arrhenius
(B) Brønsted-Lowry
✔ (C) Modified Arrhenius
(D) Operational

15. What is a conjugate acid-base pair in the reaction below?

$$NH_3(aq) + H_2O(g) \rightleftarrows OH^-(aq) + NH_4^+(aq)$$

	acid	base
✔ (A)	$H_2O(g)$	$OH^-(aq)$
(B)	$NH_3(aq)$	$NH_4^+(aq)$
(C)	$NH_4^+(aq)$	$H_2O(g)$
(D)	$OH^-(aq)$	$NH_3(aq)$

16. Which acid is weakest?

(A) $HF(aq)$
(B) $HNO_2(aq)$
✔ (C) $H_2PO_4^-(aq)$
(D) $HOOCCOO^-(aq)$

17. Which substance is amphoteric?

(A) $H_2CO_3(aq)$
✔ (B) $HCO_3^-(aq)$
(C) $CO_3^{2-}(aq)$
(D) $H_3CO_3^+(aq)$

18. What is the pOH of 0.0010 mol/L $Mg(OH)_2(aq)$?

✔ (A) 2.70
(B) 3.00
(C) 11.00
(D) 11.30

19. What is the $[H_3O^+]$ for a solution with pH = 2.42?

(A) 2.6×10^{-12} mol/L
✔ (B) 3.8×10^{-3} mol/L
(C) 8.6×10^{-2} mol/L
(D) 3.8×10^{-1} mol/L

20. If 50.0 mL of a 6.00 mol/L HCl(aq) is diluted to 250.0 mL, what is the concentration of $H^+(aq)$ in the diluted solution?

(A) 0.00150 mol/L
(B) 0.833 mol/L
✔ (C) 1.20 mol/L
(D) 1.50 mol/L

21. Which has the highest pOH?

(A) 0.5 mol/L HCl(aq)
(B) 0.5 mol/L HCN(aq)
(C) 2.0 mol/L HF(aq)
✔ (D) 2.0 mol/L HI(aq)

22. Solution A has a pH of 2.50. Solution B has a pH of 5.50. How does the hydrogen ion concentration differ between the two solutions?

(A) Solution A has one thousand times less H^+ than B.
✔ (B) Solution A has one thousand times more H^+ than B.
(C) Solution A has three times less H^+ than B.
(D) Solution A has three times more H^+ than B.

23. Which term best describes the carbonic acid (CO_3^{2-}) and bicarbonate ion (HCO_3^-) equilibrium system that regulates human blood?

✔ (A) buffer
(B) indicator
(C) standard
(D) titrant

24. What does the expression $\frac{[H_3PO_4][OH^-]}{[H_2PO_4^-]}$ represent?

(A) K_a for $H_2PO_4^-$

(B) K_a for H_3PO_4

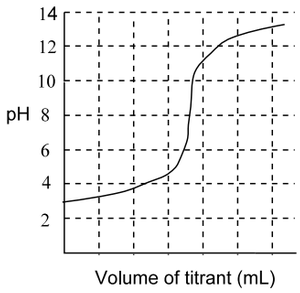
✔ (C) K_b for $H_2PO_4^-$

(D) K_b for H_3PO_4

25. Which indicator should be used for a titration with an endpoint occurring at pH = 3.6?

(A) bromocresol green
(B) indigo carmine
✔ (C) methyl orange
(D) phenolphthalein

26. What is the pH at the equivalence point of the titration below?



(A) 3.0
✔ (B) 8.0
(C) 11.0
(D) 13.0

27. Which represents the second equivalence point in a titration of $H_3BO_3(aq)$ with $OH^-(aq)$?

(A) $HBO_3^{2-}(aq) + OH^-(aq) \rightarrow BO_3^{3-}(aq) + H_2O(\ell)$

✔ (B) $H_2BO_3^-(aq) + OH^-(aq) \rightarrow HBO_3^{2-}(aq) + H_2O(\ell)$

(C) $H_3BO_3(aq) + OH^-(aq) \rightarrow H_2BO_3^-(aq) + H_2O(\ell)$

(D) $H_3BO_3(aq) + 3\ OH^-(aq) \rightarrow BO_3^{3-}(aq) + 3H_2O(\ell)$

28. Which best describes a diprotic acid?

(A) accepts two electrons
(B) accepts two protons
(C) donates two electrons
✔ (D) donates two protons

29. Which is a closed system?

(A) beaker of HCl(aq)

✔ (B) bomb calorimeter

(C) burette of $NH_3(\ell)$

(D) pipette of NaOH(aq)

30. Which has the highest average kinetic energy?

✔ (A) 125 mL of water at 95 ºC
(B) 341 mL of ethanol at 78 ºC
(C) 463 mL of apple juice at 25 ºC
(D) 515 mL of orange juice at 15 ºC

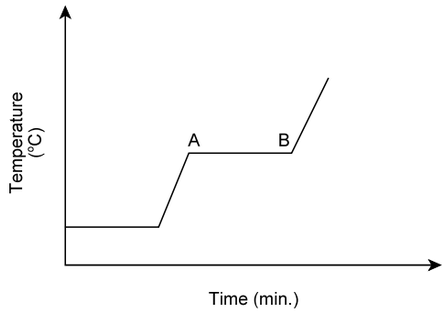
31. What is heat?

(A) average kinetic energy of the particles of a system
(B) energy change for a compound produced from its elements
(C) energy contained in a chemical bond
✔ (D) transfer of energy between a system and its surroundings

32. Which involves the greatest energy change?

(A) (s) → (ℓ)
(B) (ℓ) → (s)
✔ (C) (s) → (g)
(D) (ℓ) → (g)

33. Which best describes the energy change from point A to point B below?



(A) kinetic energy is decreasing
(B) kinetic energy is increasing
(C) potential energy is decreasing
✔ (D) potential energy is increasing

34. How much energy is gained by a 65.0 g sample of NH_3 if it is heated from 15.0 ºC to 40.0 ºC? (specific heat capacity of NH_3 = 4.70 J/g•ºC)

(A) -7.64 kJ
(B) -0.118 kJ
(C) 0.118 kJ
✔ (D) 7.64 kJ

35. How much energy is required to vaporize 15.2 g of water at 100 ºC?

(A) 6.36 kJ
✔ (B) 34.3 kJ
(C) 48.3 kJ
(D) 91.5 kJ

36. Which is used when experimentally determining the heat of reaction using calorimetry?

(A) $q_{system} = mc\Delta T$
✔ (B) $q_{system} = -q_{surroundings}$
(C) $q_{surroundings} = C\Delta T$
(D) $q_{surroundings} = n\Delta H$

37. The human body is approximately 85% water by mass. How much heat would be absorbed by a 65.0 kg person if the body temperature increases by 10.0 ºC?

(A) 8.50×10^1 kJ
✔ (B) 2.31×10^3 kJ
✔ (C) 2.72×10^3 kJ
(D) 5.53×10^3 kJ

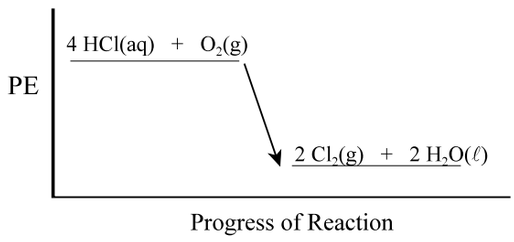
38. Which has a standard heat of formation of 0 kJ/mol?

(A) HCl(g)
✔ (B) $H_2(g)$
(C) $N_2O(g)$
(D) O(g)

39. Which best represents the reaction below?

$$4\ HCl(aq) + O_2(g) + \text{energy} \rightarrow 2\ Cl_2(g) + 2\ H_2O(\ell)$$

(A)



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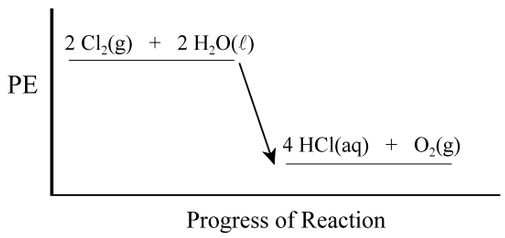
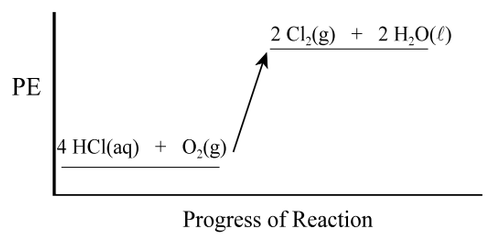
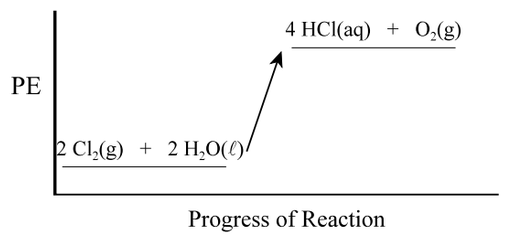


✔ (C)



(D)



40. Which is the correct order of increasing energy change?

(A) chemical < nuclear < phase
(B) chemical < phase < nuclear
✔ (C) phase < chemical < nuclear
(D) phase < nuclear < chemical

41. Which occurs during oxidation?

(A) gain of electrons
(B) gain of protons
✔ (C) loss of electrons
(D) loss of protons

42. Which equals the sum of all oxidation numbers in a polyatomic ion?

✔ (A) overall charge of the ion
(B) oxidation number of the central atom
(C) total number of atoms
(D) total number of valence electrons

43. What is the oxidation number of Cr in CrO_4^{2-}?

(A) -2
(B) +4
✔ (C) +6
(D) +8

44. Which is the reducing agent in the reaction below?

$$Cl_2 + 2\ Br^- \rightarrow 2\ Cl^- + Br_2$$

✔ (A) Br^-
(B) Br_2
(C) Cl^-
(D) Cl_2

45. Which is a redox reaction?

(A) $2\ NaCl + Pb(NO_3)_2 \rightarrow PbCl_2 + 2\ NaNO_3$
✔ (B) $2\ NO_2 + H_2O \rightarrow HNO_2 + HNO_3$
(C) $2\ NO_2 \rightarrow N_2O_4$
(D) $N_2O_3 + H_2O \rightarrow 2\ HNO_2$

46. When a solid zinc strip was placed in a blue solution of $Cu^{2+}(aq)$, the solution turned colourless. What happened to the $Cu^{2+}(aq)$?

(A) decomposed
(B) dissolved
(C) oxidized
✔ (D) reduced

47. What is the E^o for the overall reaction below?

$$3\ Co + 2\ Au^{3+} \rightarrow 3\ Co^{2+} + 2\ Au$$

(A) 1.22 V
✔ (B) 1.78 V
(C) 2.16 V
(D) 3.84 V

48. If 0.160 mol of a metal produces a 46 300 C charge, how many electrons does the metal gain in its half reaction?

(A) 1
(B) 2
✔ (C) 3
(D) 4

49. Which is a potential environmental problem with pyrometallurgy?

(A) consumes H_2O
(B) consumes O_2
(C) produces CO_2
✔ (D) produces SO_2

50. Which element is most commonly used in a fuel cell?

(A) copper
(B) fluorine
✔ (C) hydrogen
(D) zinc

PART II
Total Value: 50%

Instructions: Complete all items in this section. Your responses must be clearly presented in a well organized manner with proper use of units, formulae and significant figures where appropriate.

Value

51.(a) 1.00 g of $NaHCO_3(s)$ reacted with varying concentrations of $CH_3COOH(aq)$ over four trials at 25.0 °C. The $CO_2(g)$ produced was collected in a 28.0 mL test tube. The table below shows the data collected.

$$CH_3COOH(aq) + NaHCO_3(s) \rightarrow NaCH_3COO(aq) + CO_2(g) + H_2O(\ell)$$

Trial	$[CH_3COOH(aq)]$ (mol/L)	time to fill tube (seconds)
1	1	11
2	0.83	19
3	0.67	32
4	0.5	47

3% (i) Calculate the rate of reaction for trial 2 and 3 in mL $CO_2(g)$/s.

Rate 2 = $\frac{28 \text{ mL } CO_2}{19 \text{ s}}$ = 1.5 mL/s (1 mark)

Rate 3 = $\frac{28 \text{ mL } CO_2}{32 \text{ s}}$ = 0.88 mL/s (1 mark)

science communication skills (1 mark)

2% (ii) Using collision theory, explain the difference in the rates of reaction for trial 2 and 3.

CH_3COOH is less in trial 3 (½ mark)

therefore less collisions; less "successful" collisions (1 mark)

therefore rate is slower (½ mark)

2% (iii) The experimenter used $NaHCO_3(s)$ tablets for all trials. If the tablets were broken into pieces, estimate the rate of reaction for trial 3. Justify your answer.

Increasing the surface area (½ mark) would increase the rate of

reaction (1 mark) for trial 3 due to more particles exposed thus more

successful collisions (½ mark)

Value

4% 51.(b) 2.50 mol of $H_2(g)$ and 2.50 mol of $I_2(g)$ are placed in a 1.00 L container at 127 °C. When the equilibrium below is reached, 35.5 % of $I_2(g)$ has reacted. Calculate the value of the equilibrium constant.

	$H_2(g)$	+ $I_2(g)$	$\rightleftharpoons$	2 HI(g)	
I	**2.50**	**2.50**		**0**	
C	**- *x***	**- *x***		**+ 2*x***	
E	**2.50 - *x***	**2.50 - *x***		**2*x***	**(1 mark)**

$[I_2]_c$ = 2.50 mol/L x 0.355 = 0.887(5) mol/L = *x* **(½ mark)**

$[H_2]_{eq}$ = 2.50 - x = 2.50 - 0.887(5) = 1.61(3) mol/L **(½ mark)**

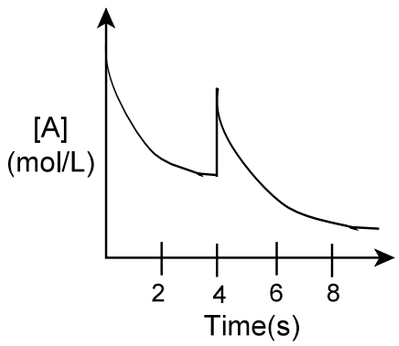
$[I_2]_{eq}$ = 2.50 - x = 2.50 - 0.887(5) = 1.61(3) mol/L **(½ mark)**

$[HI]_{eq}$ = 2x = 2(0.887(5)) = 1.77(5) mol/L **(½ mark)**

$$\mathbf{K = \frac{[HI]^2}{[H_2][I_2]} = \frac{(1.77(5))^2}{(1.61(3))^2} = 1.21}$$

(½ mark) (½ mark)

2% (c) The graph below represents the reaction, A(g) → B(g). Explain what might have caused the change in the graph at 4 s and for the period from 4 s to 8 s.



At 4 s	**[A] increases (½ mark); by the addition of more A (½ mark)**
	or by decreasing volume of container
4s → 8s	**[A] decreases (1 mark)**

3% 52.(a) Write the net ionic equation for the acid-base reaction which occurs when aqueous solutions of sodium hydrogen sulfate ($NaHSO_4$) and potassium hydrogen carbonate ($KHCO_3$) are mixed. Show all workings.

Species:	**Na^+**	**HSO_4^-**	**K^+**	**HCO_3^-**	**H_2O**	**(½ mark)**
	neutral	**A/B**	**neutral**	**A/B**	**A/B**	
		SA		**SB**		**(½ mark)**

HSO_4^- + HCO_3^- $\rightleftharpoons$ SO_4^{2-} + H_2CO_3

(½ mark) (½ mark) (½ mark) (½ mark)

Value

4% 52.(b) 25.00 mL of LiOH(aq) is neutralized by 47.62 mL of 0.0521 mol/L H_2SO_4(aq). Calculate the pH of LiOH(aq).

$$2\ LiOH(aq) + H_2SO_4(aq) \rightarrow 2\ HOH(\ell) + Li_2SO_4(aq)$$

$n(H_2SO_4) = c\ v = (0.0521\ mol/L)(0.04762\ L) = 2.48(1) \times 10^{-3}$ mol **(½ mark)**

$n(LiOH) = 2.48(1) \times 10^{-3}$ mol LiOH $\times \frac{2\ mol\ LiOH}{1\ mol\ H_2SO_4} = 4.96(2) \times 10^{-3}$ mol **(½ mark)**

$c(LiOH) = \frac{4.96(2) \times 10^{-3}\ mol}{0.02500\ L} = 0.198(5)$ mol/L **(½ mark)**

$[OH^-] = [LiOH]$ (SB / 100% dissociation / 1 : 1) **(½ mark)**

$pOH = -\log [OH^-] = -\log 0.198(5) = 0.702$ **(½ mark)**

$pH = 14.000 - pH = 14.000 - 0.702 = 13.298$ **(½ mark)**
science communication skills **(1 mark)**

4% (c) Calculate the pH of a 0.25mol/L solution of HA(aq), if $K_a = 3.6 \times 10^{-7}$.

	HA	+ **H_2O** ⇌	**H_3O^+**	**A^-**	
I	**0.25**		**0**	**0**	
C	**$-x$**		**$+x$**	**$+x$**	
E	**$0.25 - x$**		**$+x$**	**$+x$**	**(1 mark)**

check $\frac{[HA]_i}{K_a} = \frac{0.25}{3.6 \times 10^{-7}} = 690000 > 500$ thus assume $0.25 - x \sim 0.25$
(½ mark) **(½ mark)**

$K = \frac{[H_3O^+][A^-]}{[HA]}$ **(½ mark)**

$3.6 \times 10^{-7} = \frac{x^2}{0.25}$ **(½ mark)**

$x = 3.0 \times 10^{-4} = [H_3O^+]$ **(½ mark)**

$pH = -\log [H_3O^+] = -\log 3.0 \times 10^{-4} = 3.52$ **(½ mark)**

3% (d) A 0.10 mol/L aqueous solution of a weak acid HA(aq), caused litmus to turn red and methyl orange to turn yellow. Calculate the percent reaction for HA(aq).

litmus: red < 4.5 ; blue > 8.3
methyl orange: red < 3.2 ; yellow > 4.4 **(½ mark)**

thus pH is between 4.4 - 4.5 or 4.4(5) **(1 mark)**

$[H^+] = 10^{-pH} = 10^{-4.45} = 3.5(5) \times 10^{-5}$ mol/L **(½ mark)**

% rxn $= \frac{[HA]_c}{[HA]_I} \times 100\% = \frac{3.5(5) \times 10^{-5}}{0.10} \times 100\% = 0.035\ \%$ **(1 mark)**

Value

4% 53.(a) Calculate the enthalpy change for the overall reaction, $C_2H_6(g) \rightarrow 2C(s) + 3H_2(g)$. Show all workings.

- 2 x ① $C(s) + O_2(g) \rightarrow CO_2(g)$ $\Delta H = -197$ kJ

3 x ② $H_2O(\ell) \rightarrow H_2(g) + \frac{1}{2} O_2(g)$ $\Delta H = +143$ kJ

- 1 x ③ $2 CO_2(g) + 3 H_2O(\ell) \rightarrow C_2H_6(g) + {}^{7}/_{2} O_2(g)$ $\Delta H = +781$ kJ

$2 CO_2(g) \rightarrow 2 C(s) + 2 O_2(g)$ **$\Delta H = +394$ kJ** **(1 mark)**

$3 H_2O(\ell) \rightarrow 3 H_2(g) + 3/2 O_2(g)$ **$\Delta H = +429$ kJ** **(1 mark)**

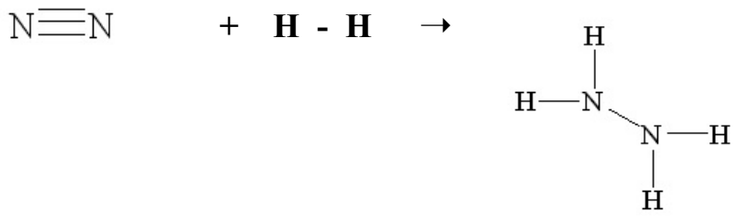
$C_2H_6(g) + {}^{7}/_{2} O_2(g) \rightarrow 2 CO_2(g) + 3 H_2O(\ell)$ **$\Delta H = -781$ kJ** **(1 mark)**

$C_2H_6(g) \rightarrow 2 C(s) + 3 H_2(g)$ **$\Delta H = +42$ kJ** **(1 mark)**

3% (b) Use the information provided to calculate the molar heat of formation for hydrazine, $N_2H_4(g)$. $N_2(g)$ has a multiple bond, while $H_2(g)$ and $N_2H_4(g)$ have single bonds only.

$$N_2(g) + 2 H_2(g) \rightarrow N_2H_4(g)$$

Bond	Energy (kJ/mol)
N - N	160
N - H	336
N≡N	945
H - H	436



1 x (N ≡ N) **2 x (H – H)** → **1 x (N – N) + 4 x (N – H)**

$\Delta H = \Sigma BE_{reactants} - \Sigma BE_{products}$
$= [(1 \times 945) + (2 \times 436)] - [(1 \times 160) + (4 \times 336)]$
$= [945 + 872] - [160 + 1344]$ **(2 marks)**
$= 1817 - 1504$ **(½ mark)**
$= 313$ kJ **(½ mark)**

Value

4% 53.(c) A new bomb calorimeter was calibrated by burning 0.125 mol of butane, $C_4H_{10}(g)$, (ΔH_{comb} = -2880 kJ/mol) resulting in a 21.7 °C increase in temperature of the calorimeter and its contents. A 12.0 g sample of chocolate is burned in the same calorimeter resulting in a 15.4 °C increase in temperature. Calculate the fuel value for the sample of chocolate.

$q_{system} = -q_{surroundings}$ **$q_{butane} = -q_{calorimeter}$** **$n\,\Delta H = -C\,\Delta T$** **$C_{calorimeter} = -\frac{(0.125\text{ mol})(-2880\text{ kJ/mol})}{21.7°C}$** **$= 16.5(9)\text{ kJ/°C}$** **(1½ mark)**	**$q_{chocolate} = C \times \Delta T$** **$= (16.5(9)\text{ kJ/°C})(15.4°C)$** **$= 255.(5)\text{ kJ}$** **(½ mark)** **$FV = \frac{q}{m} = \frac{255.(5)\text{ kJ}}{12.0\text{ g}} = 21.3\text{ kJ/g}$** **(1 mark)**

science communication skills (1 mark)

2% (d) The molar heat of a reaction can be determined by using three different methods: calorimetry, molar heat of formation values, or bond energy values. Which method is least accurate? Justify your answer.

Bond energy method (1 mark)

because bond energies are average values (1 mark) determined by the other surrounding atoms in the molecule. In the presence of different atoms same bond has different energies.

3% 54.(a) Balance the reaction below under acidic conditions.

$$Bi + Cr_2O_7^{2-} \rightarrow Bi^{3+} + Cr^{3+}$$

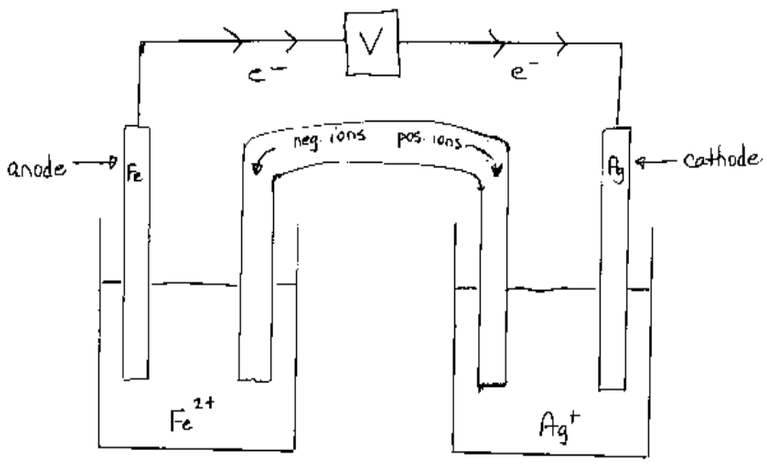
$Bi \rightarrow Bi^{3+} + 3\,e^-$ (½ mark)] x 2 (½ mark)

$6\,e^- + 14\,H^+ + Cr_2O_7^{2-} \rightarrow 2\,Cr^{3+} + 7\,H_2O$ (1 mark)

$2\,Bi + 14\,H^+ + Cr_2O_7^{2-} \rightarrow 2\,Bi^{3+} + 2\,Cr^{3+} + 7\,H_2O$ (1 mark)

Value

3% 54.(b) Sketch the electrochemical cell: $Fe(s)|Fe^{2+}(aq)\|Ag^{+}(aq)|Ag(s)$. Label the anode, cathode, direction of electron flow, and direction of flow for all ions in the salt bridge.



anode (½ mark)
cathode (½ mark)
electron flow (½ mark)
negative ions (½ mark)
positive ions (½ mark)
general shape (½ mark)

(c) The following observations were recorded for an unknown metal, M(s), under standard conditions.

$$M(s) + Cu^{2+}(aq) \rightarrow M^{2+}(aq) + Cu(s)$$
$$M(s) + Pb^{2+}(aq) \rightarrow M^{2+}(aq) + Pb(s)$$
$$M(s) + Ni^{2+}(aq) \rightarrow \text{non-spontaneous}$$

2% (i) Identify the unknown metal, M(s). Justify your answer.

$Cu^{2+} + 2\,e^- \rightarrow Cu$

$Pb^{2+} + 2\,e^- \rightarrow Pb$

metal reduces Cu^{2+} and Pb^{2+} but not Ni^{2+}

$Ni^{2+} + 2\,e^- \rightarrow Ni$ **(1 mark)**

The only metal on the chart above Ni and

below Cu and Pb is Sn.

Unknown metal is Sn (1 mark)

2% (ii) Will the unknown metal, M(s), react spontaneously with $Cd^{2+}(aq)$? Justify your answer.

Cd is below Ni on the reduction potential table. **(1 mark)**

Since M did not reduce Ni^{2+} it will not reduce Cd^{2+} **(1 mark)**