CHAPTER 4
CHEMICAL REACTIONS & STOICHIOMETRY

1. Antimony can react with chlorine gas to give antimony trichloride.
   \[ \text{_____ Sb(s) } + \text{_____ Cl}_2(g) \rightarrow \text{_____ SbCl}_3(l) \]
   Which of the following is the most correct set of stoichiometric coefficients to balance this equation?
   (a) 1, 1, 1  (b) 1, 3, 2  (c) 4, 6, 4  (d) 2, 3, 2

2. Octane burns in air to give carbon dioxide and water.
   \[ \text{_____ C}_8\text{H}_{18}(l) + \text{_____ O}_2(g) \rightarrow \text{_____ CO}_2(g) + \text{_____ H}_2\text{O}(g) \]
   Which of the following is the most correct set of stoichiometric coefficients to balance this equation?
   (a) 2, 25, 16, 18  (b) 2, 12, 8, 9  (c) 1, 12, 8, 9  (d) 1, 6, 8, 9

3. The original method of making ammonia was to react calcium cyanamide with water according to the following reaction.
   \[ \text{_____ CaCN}_2(s) + \text{_____ H}_2\text{O}(l) \rightarrow \text{_____ CaCO}_3(s) + \text{_____ NH}_3(g) \]
   Which of the following is the most correct set of stoichiometric coefficients to balance this equation?
   (a) 2, 6, 2, 4  (b) 4, 2, 6, 2  (c) 1, 3, 1, 2  (d) 1, 1, 1, 1

4. Write and balance the equation for the combustion of ascorbic acid (C\textsubscript{6}H\textsubscript{8}O\textsubscript{6}, vitamin C) in oxygen to give CO\textsubscript{2} and H\textsubscript{2}O.
   (a) \[ \text{C}_6\text{H}_8\text{O}_6(s) + 3 \text{O}_2(g) \rightarrow 6 \text{CO}_2(g) + 4 \text{H}_2\text{O}(g) \]
   (b) \[ \text{C}_6\text{H}_8\text{O}_6(s) + 5 \text{O}_2(g) \rightarrow 6 \text{CO}_2(g) + 4 \text{H}_2\text{O}(g) \]
   (c) \[ 2 \text{C}_6\text{H}_8\text{O}_6(s) + 5 \text{O}_2(g) \rightarrow 12 \text{CO}_2(g) + 8 \text{H}_2\text{O}(g) \]
   (d) \[ \text{C}_6\text{H}_8\text{O}_6(s) + \text{O}_2(g) \rightarrow \text{CO}_2(g) + \text{H}_2\text{O}(g) \]

5. Write and balance the equation for the combustion of ferrocene, C\textsubscript{10}H\textsubscript{10}Fe, in oxygen to give iron(III) oxide, carbon dioxide, and water.
   (a) \[ \text{C}_{10}\text{H}_{10}\text{Fe(s)} + \text{O}_2(g) \rightarrow 2 \text{Fe}_2\text{O}_3(s) + 10 \text{CO}_2(g) + 5 \text{H}_2\text{O}(g) \]
   (b) \[ \text{C}_{10}\text{H}_{10}\text{Fe(s)} + 13 \text{O}_2(g) \rightarrow \text{FeO(s)} + 10 \text{CO}_2(g) + 5 \text{H}_2\text{O}(g) \]
   (c) \[ 2 \text{C}_{10}\text{H}_{10}\text{Fe(s)} + 26 \text{O}_2(g) \rightarrow \text{Fe}_2\text{O}_3(s) + 20 \text{CO}_2(g) + 10 \text{H}_2\text{O}(g) \]
   (d) \[ 4 \text{C}_{10}\text{H}_{10}\text{Fe(s)} + 53 \text{O}_2(g) \rightarrow 2 \text{Fe}_2\text{O}_3(s) + 40 \text{CO}_2(g) + 20 \text{H}_2\text{O}(g) \]
15. Nitrogen oxide is oxidized in air to give brown nitrogen dioxide.

\[ 2 \text{NO}(g) + \text{O}_2(g) \rightarrow 2 \text{NO}_2(g) \]

If you have 2.2 moles of NO,
(a) you need 2.2 moles of O\(_2\) for complete reaction and produce 2.2 moles of NO\(_2\).
(b) you need 1.1 moles of O\(_2\) for complete reaction and produce 2.2 moles of NO\(_2\).
(c) you need 1.1 moles of O\(_2\) for complete reaction and produce 3.3 moles of NO\(_2\).
(d) you need 1.0 moles of O\(_2\) for complete reaction and produce 2.0 moles of NO\(_2\).

16. Aluminum reacts with oxygen to give aluminum(III) oxide.

\[ 4 \text{Al}(s) + 3 \text{O}_2(g) \rightarrow 2 \text{Al}_2\text{O}_3(s) \]

If you have 6.0 moles of Al,
(a) you need 3.0 moles of O\(_2\) for complete reaction and produce 2.0 moles of Al\(_2\)O\(_3\).
(b) you need 18.0 moles of O\(_2\) for complete reaction and produce 12.0 moles of Al\(_2\)O\(_3\).
(c) you need 3.0 moles of O\(_2\) for complete reaction and produce 2.0 moles of Al\(_2\)O\(_3\).
(d) you need 4.5 moles of O\(_2\) for complete reaction and produce 3.0 moles of Al\(_2\)O\(_3\).

17. The very stable compound SF\(_6\) is made by burning sulfur in an atmosphere of fluorine.

\[ \text{S}_8(s) + 24 \text{F}_2(g) \rightarrow 8 \text{SF}_6(g) \]

If you need 2.50 moles of SF\(_6\), you will need to use
(a) 0.313 moles of S\(_8\) and 7.50 moles of F\(_2\).
(b) 1.00 moles of S\(_8\) and 24.0 moles of F\(_2\).
(c) 0.125 moles of S\(_8\) and 3.00 moles of F\(_2\).
(d) 8.00 moles of S\(_8\) and 24.0 moles of F\(_2\).

18. Many metals react with halogens to give metal halides. For example,

\[ \text{Fe}(s) + \text{Cl}_2(g) \rightarrow \text{FeCl}_2(s) \]

If you begin with 10.0 g of iron,
(a) you will need 10.0 g of Cl\(_2\) for complete reaction and will produce 22.7 g of FeCl\(_2\).
(b) you will need 12.7 g of Cl\(_2\) for complete reaction and will produce 10.0 g of FeCl\(_2\).
(c) you will need 12.7 g of Cl\(_2\) for complete reaction and will produce 22.7 g of FeCl\(_2\).
(d) you will need 10.0 g of Cl\(_2\) for complete reaction and will produce 10.0 g of FeCl\(_2\).

19. Like many metals, aluminum reacts with a halogen to give a metal halide.

\[ 2 \text{Al}(s) + 3 \text{Br}_2(l) \rightarrow \text{Al}_2\text{Br}_6(s) \]

If you begin with 2.56 g of Al, how many grams of Br\(_2\) (molar mass = 159.8 g/mol) are required for complete reaction?
(a) 3.84 g
(b) 10.1 g
(c) 15.1 g
(d) 22.7 g
20. Many metals react with halogens to give metal halides. For example, 
2 Al(s) + 3 Br₂(l) → Al₂Br₆(s)
If you begin with 2.56 g of Al, how many grams of Al₂Br₆ (molar mass = 533.4 g/mol) could you produce if you use excess Br₂?
(a) 17.7 g  (b) 20.1 g  (c) 25.3 g  (d) 50.6 g

21. Many metal halides react with water to produce the metal oxide (or hydroxide) and the appropriate hydrogen halide. For example, 
TiCl₄(l) + 2 H₂O(g) → TiO₂(s) + 4 HCl(g)
If you begin with 14.0 g of TiCl₄ (molar mass = 189.7 g/mol),
(a) you will need 2.66 g of H₂O for complete reaction and will produce 5.90 g of TiO₂ and 10.8 g of HCl.
(b) you will need 1.33 g of H₂O for complete reaction and will produce 5.90 g of TiO₂ and 10.8 g of HCl.
(c) you will need 2.66 g of H₂O for complete reaction and will produce 8.8 g of TiO₂ and 8.8 g of HCl.
(d) you will need 1.33 g of H₂O for complete reaction and will produce 7.7 g of TiO₂ and 7.7 g of HCl.

22. Assume you allow 28.0 g of titanium(IV) chloride (molar mass = 189.7 g/mol) to react with 6.00 g of water. What is theoretical yield of titanium(IV) oxide?
TiCl₄(l) + 2 H₂O(g) → TiO₂(s) + 4 HCl(g)
(a) 5.90 g  (b) 6.00 g  (c) 11.8 g  (d) 13.3 g

23. Gaseous sulfur dioxide, SO₂, can be removed from smokestacks by treatment with limestone and oxygen.
2 SO₂(g) + 2 CaCO₃(s) + O₂(g) → 2 CaSO₄(s) + 2 CO₂(g)
(i) How many grams of CaCO₃ are required to remove 150. g of SO₂?
(a) 117 g  (b) 150. g  (c) 234 g  (d) 468 g
(ii) How many grams of CaSO₄ are formed when 150. g of SO₂ is consumed completely?
(a) 150. g  (b) 136 g  (c) 159 g  (d) 319 g

24. The reaction of methane and water is one way to prepare hydrogen.
CH₄(g) + 2 H₂O(g) → CO₂(g) + 4 H₂(g)
If you begin with 995 g of CH₄ and 2510 g of water, what is the maximum theoretical yield of H₂?
(a) 125 g  (b) 500. g  (c) 281 g  (d) 562 g
25. Ammonia gas can be prepared by the following reaction:

$$\text{CaO(s)} + 2 \text{NH}_4\text{Cl(s)} \rightarrow 2 \text{NH}_3(g) + \text{H}_2\text{O(g)} + \text{CaCl}_2(s)$$

If you mix 112 g of CaO and 224 g of NH$_4$Cl, what is the theoretical yield of NH$_3$?

(a) 34.0 g  (b) 35.5 g  (c) 68.0 g  (d) 71.2 g

26. Aluminum chloride, AlCl$_3$, can be produced by treating scrap aluminum with chlorine gas.

$$2 \text{Al(s)} + 3 \text{Cl}_2(g) \rightarrow 2 \text{AlCl}_3(s)$$

If you start with 5.40 g of Al and 8.10 g of Cl$_2$, what is the maximum number of grams of AlCl$_3$ (molar mass = 133.3 g/mol) that can be produced?

(a) 10.1 g  (b) 13.5 g  (c) 26.6 g  (d) 5.40 g

27. Uranium(VI) oxide reacts with bromine trifluoride to give uranium(IV) fluoride, an important step in the purification of uranium ore.

$$6 \text{UO}_3(s) + 8 \text{BrF}_3(l) \rightarrow 6 \text{UF}_4(s) + 4 \text{Br}_2(l) + 9 \text{O}_2(g)$$

If you begin with 365 g each of UO$_3$ and BrF$_3$, what is the maximum yield theoretically possible for UF$_4$?

(a) 534 g  (b) 401 g  (c) 837 g  (d) 1120 g

28. Aspirin is produced by the reaction of salicylic acid ($M = 138.1$ g/mol) and acetic anhydride ($M = 180.2$ g/mol).

$$2 \text{C}_7\text{H}_6\text{O}_3(s) + \text{C}_4\text{H}_6\text{O}_3(l) \rightarrow 2 \text{C}_9\text{H}_8\text{O}_4(s) + \text{H}_2\text{O}(l)$$

salicylic acid  acetic anhydride  aspirin

If you mix 100. g of each of the reactants, how many grams of aspirin ($M = 180.16$ g/mol) can theoretically be obtained?

(a) 65.2 g aspirin  (b) 130. g aspirin  (c) 200. g aspirin  (d) 236 g aspirin

29. Phosphoric acid is made from phosphate rock, one form of which is apatite, Ca$_5$(PO$_4$)$_3$F (molar mass = 504.3 g/mol).

$$\text{Ca}_5(\text{PO}_4)_3\text{F(s)} + 5 \text{H}_2\text{SO}_4(aq) \rightarrow 5 \text{CaSO}_4(s) + 3 \text{H}_3\text{PO}_4(aq) + \text{HF(aq)}$$

If you use 100. g of apatite and 500. g of sulfuric acid (molar mass = 98.07 g/mol), what is the maximum possible yield of phosphoric acid (97.99 g/mol)?

(a) 300. g  (b) 19.4 g  (c) 58.2 g  (d) 600. g

30. Hydrazine, N$_2$H$_4$, is an important industrial reagent. It is synthesized by the Raschig process.

$$2 \text{NaOH} + \text{Cl}_2 + 2 \text{NH}_3 \rightarrow \text{N}_2\text{H}_4 + 2 \text{NaCl} + 2 \text{H}_2\text{O}$$

If you combine 100. g each of NaOH, Cl$_2$, and NH$_3$, some amount of two of the three reactants will be left when the reaction is complete. The two reactants that are left over are

(a) NaOH and Cl$_2$  (b) NaOH and NH$_3$  (c) Cl$_2$ and NH$_3$
31. Ammonia gas can be prepared by the reaction of a basic oxide like calcium oxide with ammonium chloride, an acidic salt.

\[
\text{CaO(s)} + 2 \text{NH}_4\text{Cl(s)} \rightarrow 2 \text{NH}_3(g) + \text{H}_2\text{O(g)} + \text{CaCl}_2\text{(s)}
\]

If you isolate exactly 100. g of NH\(_3\), but should have isolated 136 g in theory, what is the percentage yield of ammonia?

(a) 36.8%  
(b) 73.5%  
(c) 90.0%  
(d) 71.2%

32. The valuable compound diborane, B\(_2\text{H}_6\), can be made by the reaction

\[
2 \text{NaBH}_4\text{(s)} + \text{I}_2\text{(s)} \rightarrow \text{B}_2\text{H}_6\text{(g)} + 2 \text{NaI(s)} + \text{H}_2\text{(g)}
\]

You use 1.203 g of NaBH\(_4\) and excess iodine. If you isolate 0.295 g of B\(_2\text{H}_6\), the percentage yield of B\(_2\text{H}_6\) is

(a) 95.0%  
(b) 67.1%  
(c) 50.0%  
(d) 33.5%

33. Nitrogen gas can be prepared in the laboratory by the reaction of ammonia with copper(II) oxide according to the following unbalanced equation.

\[
\text{NH}_3\text{(g)} + \text{CuO(s)} \rightarrow \text{N}_2\text{(g)} + \text{Cu(s)} + \text{H}_2\text{O(g)}
\]

If you pass 26.3 g of gaseous NH\(_3\) over a bed of solid CuO (in stoichiometric excess), how many grams of N\(_2\) can be isolated?

(a) 21.6 g  
(b) 28.8 g  
(c) 43.3 g  
(d) 86.5 g

34. Disulfur dichloride can be made by allowing chlorine gas to react with molten sulfur.

\[
\text{S}_8\text{(l)} + 4 \text{Cl}_2\text{(g)} \rightarrow 4 \text{S}_2\text{Cl}_2\text{(g)}
\]

If you begin with 12.0 g of S\(_8\) and 6.35 g of Cl\(_2\), and you isolate only 7.99 g of S\(_2\)Cl\(_2\), what is the percentage yield of S\(_2\)Cl\(_2\)?

(a) 80.4%  
(b) 48.7%  
(c) 30.1%  
(d) 60.1%

35. 1.056 g of a metal carbonate, containing an unknown metal M, were heated to give the metal oxide and 0.376 g CO\(_2\).

\[
\text{MCO}_3\text{(s)} + \text{heat} \rightarrow \text{MO(s)} + \text{CO}_2\text{(g)}
\]

What is the identity of the metal M?

(a) M = Ni  
(b) M = Cu  
(c) M = Zn  
(d) M = Ba

36. Styrene, the building block of polystyrene, is a hydrocarbon, a compound consisting only of C and H. If you burn 0.438 g of the compound, and find that it produces 1.481 g of CO\(_2\) and 0.303 g of H\(_2\)O, determine the empirical formula of the compound.

(a) CH  
(b) C\(_2\)H  
(c) C\(_8\)H\(_5\)  
(d) C\(_7\)H\(_8\)
37. Mesitylene is a liquid hydrocarbon, a compound consisting only of C and H. If you burn 0.115 g of the compound, and find that it produces 0.379 g of CO\(_2\) and 0.1035 g of H\(_2\)O, determine the empirical formula of the compound.
(a) CH \hspace{1cm} (b) C\(_2\)H\(_3\)
(c) C\(_3\)H\(_4\) \hspace{1cm} (d) C\(_9\)H\(_{10}\)

38. Phenanthrene is a hydrocarbon, a compound consisting only of C and H. If you burn 0.215 g of the compound, and find that it produces 0.747 g of CO\(_2\) and 0.109 g of H\(_2\)O, determine the empirical formula of the compound.
(a) CH\(_3\) \hspace{1cm} (b) C\(_2\)H
(c) C\(_7\)H\(_5\) \hspace{1cm} (d) C\(_7\)H\(_8\)

39. Toluene is an aromatic hydrocarbon, a compound composed only of C and H. If you burn 0.366 g of the compound, and find that it produces 1.22 g of CO\(_2\) and 0.286 g of H\(_2\)O, determine the empirical formula of the compound.
(a) CH \hspace{1cm} (b) C\(_3\)H\(_5\)
(c) C\(_5\)H\(_7\) \hspace{1cm} (d) C\(_7\)H\(_8\)

40. Propionic acid is an organic acid, a compound containing only C, H, and O. If you burn 0.236 g of the acid completely, and isolate 0.421 g of CO\(_2\) and 0.172 g of H\(_2\)O, what is the empirical formula of the acid?
(a) CHO \hspace{1cm} (b) C\(_3\)H\(_3\)O\(_2\)
(c) C\(_3\)H\(_6\)O\(_2\) \hspace{1cm} (d) CH\(_3\)O

41. Quinone, which is used in the dye industry and in photography, is an organic compound containing only C, H, and O. What is the empirical formula of the compound if you find that 0.105 g of the compound give 0.257 g of CO\(_2\) and 0.0350 g of H\(_2\)O when burned completely?
(a) C\(_3\)H\(_2\)O \hspace{1cm} (b) C\(_2\)H\(_2\)O
(c) CHO \hspace{1cm} (d) CH\(_2\)O

42. Vinyl acetate, a compound containing only C, H, and O, is the basis of certain plastics. To determine its empirical formula you burn 0.178 g and find it produces 0.364 g of CO\(_2\) and 0.112 g of H\(_2\)O. What is the empirical formula of vinyl acetate?
(a) C\(_3\)H\(_2\)O \hspace{1cm} (b) C\(_2\)H\(_3\)O
(c) C\(_2\)H\(_2\)O \hspace{1cm} (d) CH\(_2\)O

43. Silicon and hydrogen form a series of interesting compounds, Si\(_x\)H\(_y\). To find the formula of one of them, you take a 6.22 g sample of the compound and burn it in oxygen. On doing so, all of the Si is converted to 11.64 g of SiO\(_2\) and all of the H to 6.980 g of H\(_2\)O. What is the empirical formula of the silicon compound?
(a) SiH\(_4\) \hspace{1cm} (b) SiH\(_3\)
(c) Si\(_3\)H\(_8\) \hspace{1cm} (d) Si\(_2\)H\(_5\)
44. To find the formula of a compound composed of iron and carbon monoxide, Fe\(_x\)(CO)\(_y\), you burn the compound in pure oxygen according to the following, *unbalanced* equation.

\[ \text{Fe}_x(\text{CO})_y(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{Fe}_2\text{O}_3(\text{s}) + \text{CO}_2(\text{g}) \]

If you burn 1.959 g of Fe\(_x\)(CO)\(_y\) and find 0.860 g of Fe\(_2\)O\(_3\) and 2.133 g of CO\(_2\), what is the empirical formula of Fe\(_x\)(CO)\(_y\)?

(a) Fe(CO)\(_4\)  \hspace{1cm} (b) Fe\(_2\)(CO)\(_9\)
(c) Fe(CO)\(_5\)  \hspace{1cm} (d) Fe(CO)\(_6\)

45. Boron forms an extensive series of compounds with hydrogen, all with the general formula B\(_x\)H\(_y\). To analyze one of these compounds you burn it in air and isolate the boron in the form of B\(_2\)O\(_3\) and the hydrogen in the form of water according to the following *unbalanced* equation.

\[ \text{B}_x\text{H}_y(\text{s}) + \text{excess O}_2(\text{g}) \rightarrow \text{B}_2\text{O}_3(\text{s}) + \text{H}_2\text{O}(\text{g}) \]

If you find that 0.148 g of B\(_x\)H\(_y\) give 0.422 g of B\(_2\)O\(_3\) when burned in excess O\(_2\), what is the empirical formula of B\(_x\)H\(_y\)?

(a) BH\(_3\)  \hspace{1cm} (b) B\(_2\)H\(_5\)
(c) B\(_3\)H\(_5\)  \hspace{1cm} (d) B\(_5\)H\(_7\)

46. You have a mixture of CuSO\(_4\) and CuSO\(_4\) \(\cdot\) 5 H\(_2\)O. The mixture has a mass of 1.245 g, but, after heating to drive off all the water, the mass is only 0.832 g. What is the weight percent of CuSO\(_4\) \(\cdot\) 5 H\(_2\)O in the mixture?

(a) 91.9%  \hspace{1cm} (b) 50.0%
(c) 8.10%  \hspace{1cm} (d) 36.2%

47. Diborane, B\(_2\)H\(_6\), can be made by the reaction

\[ 2 \text{NaBH}_4(\text{s}) + \text{I}_2(\text{s}) \rightarrow \text{B}_2\text{H}_6(\text{g}) + 2 \text{NaI}(\text{s}) + \text{H}_2(\text{g}) \]

If you use 1.203 g of NaBH\(_4\) and 3.750 g of iodine, what is the maximum theoretical yield of B\(_2\)H\(_6\)?

(a) 0.409 g  \hspace{1cm} (b) 0.440 g
(c) 0.204 g  \hspace{1cm} (d) 0.880 g

48. Aluminum bromide is a valuable laboratory chemical. If you use 25.0 mL of liquid bromine (density = 3.1023 g/mL) and excess aluminum metal, what is the maximum theoretical yield of Al\(_2\)Br\(_6\)?

\[ 2 \text{Al}(\text{s}) + 3 \text{Br}_2(\ell) \rightarrow \text{Al}_2\text{Br}_6(\text{s}) \]

(a) 64.7 g  \hspace{1cm} (b) 129 g
(c) 86.3 g  \hspace{1cm} (d) 259 g
49. Bromine trifluoride reacts with metal oxides to evolve oxygen quantitatively. For example,

\[ 3 \text{TiO}_2(s) + 4 \text{BrF}_3(l) \rightarrow 3 \text{TiF}_4(s) + 2 \text{Br}_2(l) + 3 \text{O}_2(g) \]

Suppose you wish to use this reaction to determine the weight percent of TiO\(_2\) in a sample of ore. To do this you collect the O\(_2\) gas from the reaction. If you find that 2.367 g of the TiO\(_2\)-containing ore evolve 143 mg of O\(_2\), what is the weight percent of TiO\(_2\) in the sample?

(a) 7.54%  (b) 15.1%  (c) 30.2%  (d) 84.9%

50. Electrolysis of aqueous sodium chloride is an important industrial process, since the products are commercially important chlorine, hydrogen, and sodium hydroxide.

\[ 2 \text{NaCl}(aq) + 2 \text{H}_2\text{O}(l) \rightarrow \text{Cl}_2(g) + \text{H}_2(g) + 2 \text{NaOH}(aq) \]

Assuming you begin with 293 g of NaCl, answer the following questions:

(i) How many grams of Cl\(_2\) are theoretically obtainable?

(a) 71.0 g  (b) 147 g  (c) 178 g  (d) 710. g

(ii) How many grams of NaOH are theoretically obtainable?

(a) 383 g  (b) 201. g  (c) 100. g  (d) 40.0 g

(iii) How many grams of water must be consumed for complete reaction?

(a) 18.0 g  (b) 36.0 g  (c) 90.3 g  (d) 180. g

(iv) If you have actually isolated only 3.50 g of H\(_2\), the percentage yield of H\(_2\) is

(a) 90.0%  (b) 69.1%  (c) 35.0%  (d) 14.0%

ANSWERS — CHAPTER 4

1. d  11. d  21. a
2. a  12. b  22. c
3. c  13. c  23. i = c, ii = d
4. b  14. d  24. b
5. d  15. b  25. c
6. b  16. d  26. a
7. c  17. a  27. b
8. a  18. c  28. b
9. d  19. d  29. c
10. b  20. c  30. c
31. b  41. a
32. b  42. b
33. a  43. a
34. d  44. b
35. b  45. d
36. a  46. a
37. c  47. b
38. c  48. c
39. d  49. b
40. c  50. i = c, ii = b, iii = c, iv = b