# Foreword

Through the wealth of experience of our heavily credentialed coaches who are specialists in their respective fields, we have compiled this booklet so that it serves as a study companion to you wherever you go.

This is an excerpt of our summary booklet, which contains snippets of core concepts that have been summarised into bite-sized pieces for your self-revision and reference.

Due to the wide scope of the entire GCE A-Level syllabus, we regret that we are not able to fit the entire syllabus into this Summary Booklet. Despite that, we hope that you find the content useful for your daily learning and studies.

If you wish to obtain the full version of this summary booklet, please contact us to arrange for a trial lesson at any of our Aspire Hub centres across the country. We'll be happy to share the full set of summary notes once you have attended our trial lesson.

If you need support with your schoolwork or self-revision, please contact us - we are more than happy to impart our knowledge to you to give you the extra edge over your peers!

Happy reading and all the best in your academic endeavours!

***Alex Leong***
*General Manager*
*Aspire Hub Education Group*

# Table of Content



*The full version of our summary booklet also covers the following:*
*Arithmetic and Geometric Progressions, Sigma Notation, Differentiation, Complex Numbers*

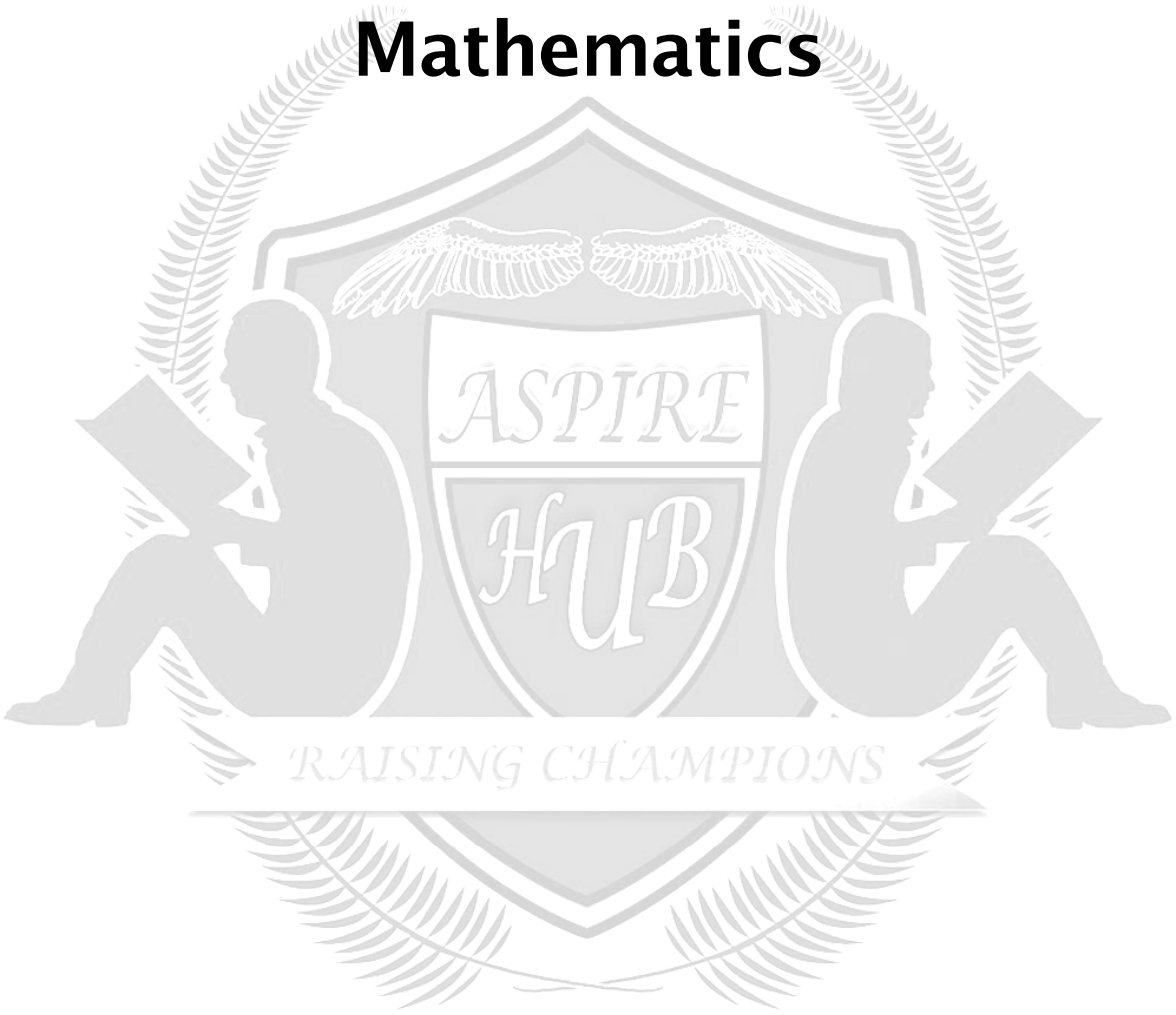


*The full version of our summary booklet also covers the following:*
*Alkenes, Aromatic Compounds, Halogen Compounds and Derivatives, Hydroxyl Compounds, Phenols, Carbonyl Compounds*



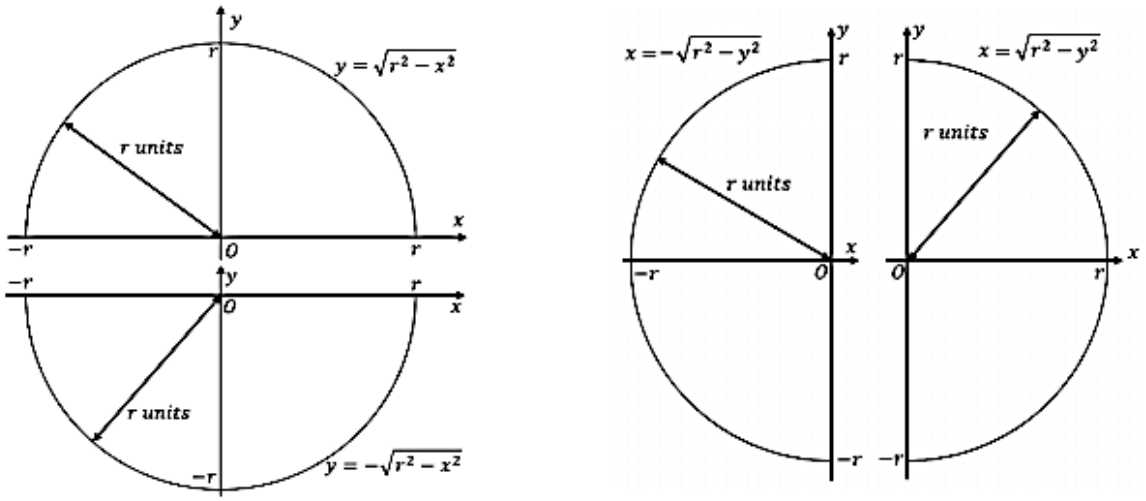
*The full version of our summary booklet also includes sample essays on the following:*
*Market Failure, Firms & Decisions/Market Structure, Macroeconomics - Deflation.& Interest Rate Policy, International Trade & Globalisation*

# Mathematics



# GRAPHING AND TRANSFORMATIONS OF GRAPH

## Equations of Semi-Circles

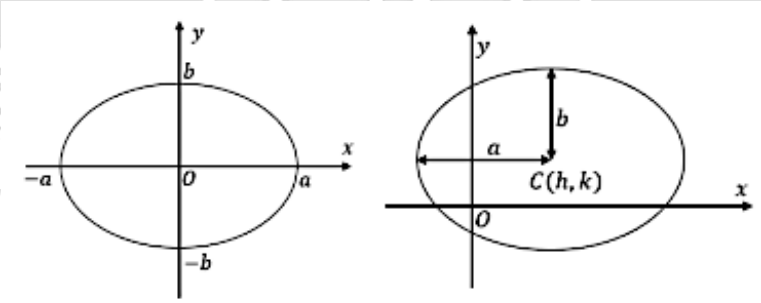



Derived from equation of circle $(x-a)^2 + (y-b)^2 = r^2$

1. Let $y$ as the subject to have the top half or the bottom half of the circle.
2. Let $x$ as the subject to have the left half or the right half of the circle.

Note that it's not allowed to manipulate the given equation (ex: $y = \sqrt{r^2 - x^2}$) back into a normal circle equation and draw the full circle instead.

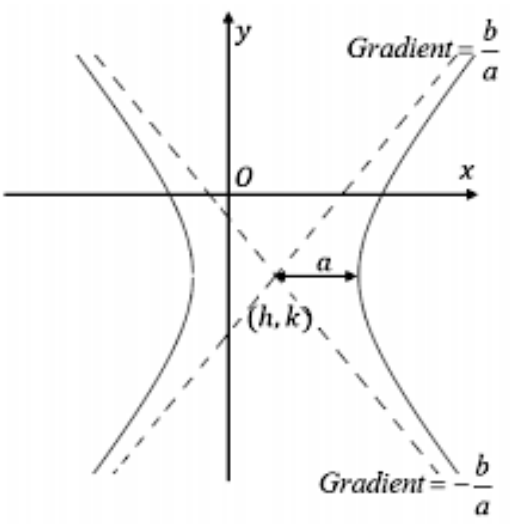
## Equation of Ellipse



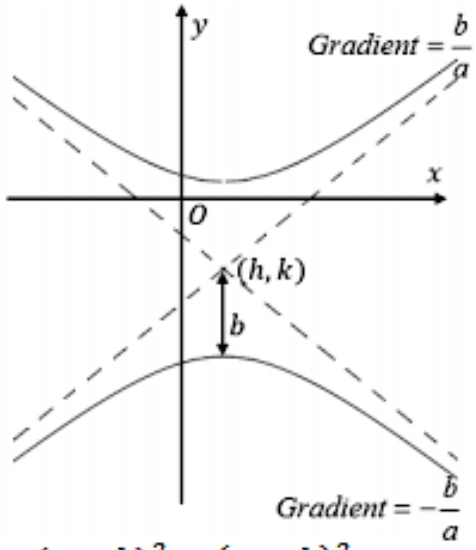

$$\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} = 1$$

1. $(h, k)$ is the centre of the ellipse (similar structure to circle).
2. $a$ and $b$ are the horizontal and vertical radius from the centre of ellipse.

## Equation of Hyperbola



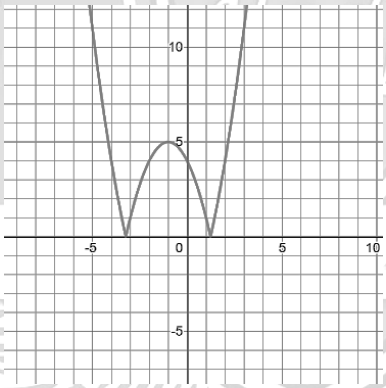
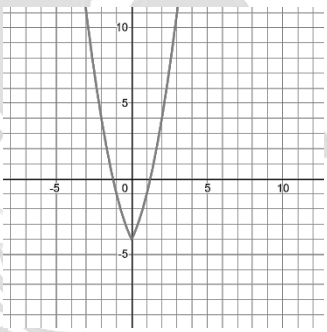

$$\frac{(x-h)^2}{a^2} - \frac{(y-k)^2}{b^2} = 1$$




$$-\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} = 1$$

1. Hyperbolas have similar equations to ellipse, except for the negative sign.
2. $(h, k)$ is the centre of the hyperbola.
3. $\pm\frac{b}{a}$ acts as the gradient of the two diagonal asymptotes of the hyperbola.
4. If the negative sign is placed on the $\frac{(x-h)^2}{a^2}$, therefore the hyperbola is a spread vertically. Vice versa for $\frac{(y-k)^2}{b^2}$.

## Transformation of graphs

| Transformation | Vertical Transformation | Horizontal Transformation |
|---|---|---|
| Translation | $a$ units to the **positive** $y$ direction:<br>Replace $y$ by $\boldsymbol{y-a}$<br>e.g. $y=x^2 \rightarrow y=x^2+a$<br>Upward movement | $b$ units to the **positive** $x$ direction:<br>Replace $x$ by $\boldsymbol{x-b}$<br>e.g. $y=x^2 \rightarrow y=(x-b)^2$<br>Rightward movement |
| | $a$ units to the **negative** $y$ direction:<br>Replace $y$ by $\boldsymbol{y+a}$<br>e.g. $y=x^2 \rightarrow y=x^2-a$<br>Downward movement | $b$ units to the **negative** $x$ direction:<br>Replace $x$ by $\boldsymbol{x+b}$<br>e.g. $y=x^2 \rightarrow y=(x+b)^2$<br>Leftward movement |
| Scaling | Scaling by factor of $a$ parallel to the $y$-axis<br>Replace $y$ by $\frac{y}{a}$<br>e.g. $y=\sin x \rightarrow \frac{y}{a}=\sin x$<br>$\rightarrow y=a\sin x$ | Scaling by factor of $b$ parallel to the $x$-axis<br>Replace $x$ by $\frac{x}{b}$<br>e.g. $y=\sin x \rightarrow y=\sin\frac{x}{b}$ |
| Reflection | Reflection to the $x$-axis<br>Replace $y$ with $-y$<br>e.g. $y=x+2 \rightarrow -y=x+2$<br>$\rightarrow y=-x-2$ | Reflection to the $y$-axis<br>Replace $x$ with $-x$<br>e.g. $y=x+2 \rightarrow y=-x+2$ |
| Modulus | Reflect all parts of the graph below $x$-axis<br>$y=x^2+2x-4 \rightarrow y=\lvert x^2+2x-4\rvert$<br>  | Delete parts of the graph where $x<0$<br>Sketch the graph where $x>0$, and draw its reflection onto the $y$-axis<br>$y=x^2+2x-4 \rightarrow y=\lvert x^2\rvert+2\lvert x\rvert-4$<br>  |

**Rule of thumb:**


1. **T** for Translate and **S** for Scaling. $x$-axis always comes first.
2. Reflection is under **S.** Between scaling or reflecting, the order doesn't matter.

**Composite Transformation**

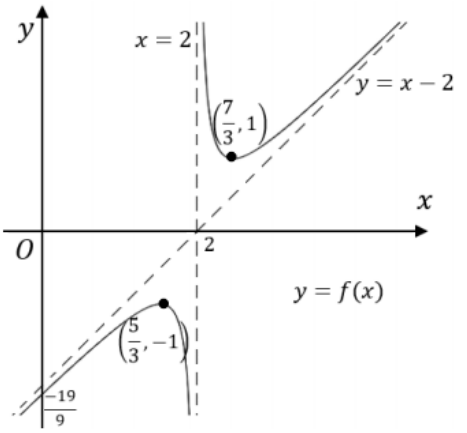
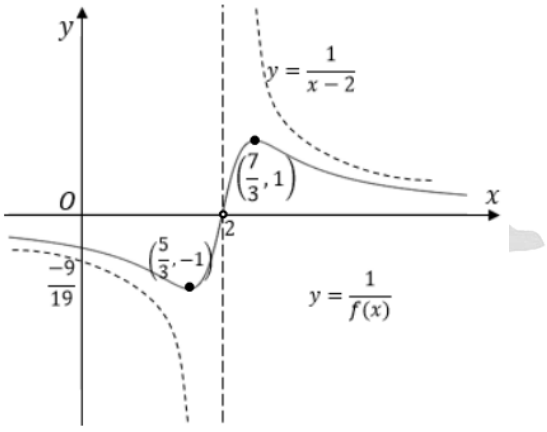
Ex: transforming $y = f(x)$ that undergoes the following transformations:

A. Translation of 2 units to the positive $x$ direction.
B. Scaling parallel to $x$-axis by factor of $\frac{1}{2}$
C. Reflection to the $y$-axis
D. Translation of 1 unit to the negative $y$ direction

$$y = f(x) \xrightarrow{\mathbf{A}} y = f(x - \mathbf{2}) \xrightarrow{\mathbf{B}} y = f(\mathbf{2}x - 2) \xrightarrow{\mathbf{C}} y = f(-2x - 2) \xrightarrow{\mathbf{D}} y = f(-2x - 2) - \mathbf{1}$$

Let $y = 1 + e^x$

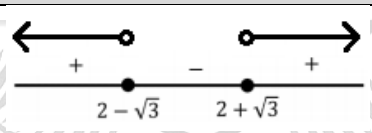
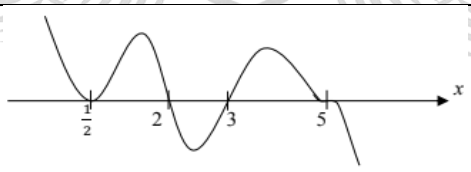
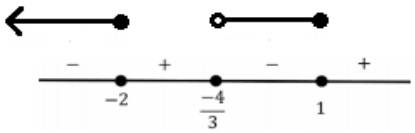
$$y = 1 + e^x \xrightarrow{\mathbf{A}} y = 1 + e^{x-2} \xrightarrow{\mathbf{B}} y = 1 + e^{2x-2} \xrightarrow{\mathbf{C}} y = 1 + e^{-2x-2} \xrightarrow{\mathbf{D}} y = e^{-2x-2}$$

| **Reciprocal Graph $y = \frac{1}{f(x)}$** | |
|---|---|
| $\boldsymbol{y = f(x)}$ | $\boldsymbol{y = \frac{1}{f(x)}}$ |
| Point $(x, y)$ | Point $(x, \frac{1}{y})$ |
| $x$-intercepts<br>$y$-intercepts | Vertical Asymptotes<br>$\left(0, \frac{1}{y}\right)$ |
| Vertical Asymptotes<br>Horizontal Asymptotes $y = a$ | $x$-intercepts<br>Horizontal Asymptotes $y = \frac{1}{a}$ |
| Maximum Point<br>Minimum Point | Minimum Point<br>Maximum Point |
| $f(x) > 0\,;\, f(x) < 0$ | $\frac{1}{f(x)} > 0\,;\, \frac{1}{f(x)} < 0$ |
| $y \to 0$<br>$y \to \infty$ | $\frac{1}{y} \to \pm\infty$<br>$y \to 0$ |
| Increasing Function<br>Decreasing Function | Decreasing Function<br>Increasing Function |
|  |  |

| **Gradient Graph $y = f'(x)$** | |
|---|---|
| $y = f(x)$ | $y = f'(x)$ |
| Vertical Asymptotes<br>Horizontal Asymptotes $y = a$<br>Oblique Asymptotes $y = mx + c$ | Vertical Asymptotes (unaffected)<br>Horizontal Asymptotes $y = 0$<br>Oblique Asymptotes $y = m$ |
| Stationary point (Max/Min point)<br>Inflexion point (increasing)<br>Inflexion point (decreasing) | $x$-intercept<br>Maximum point<br>Minimum point |
| Gradient $> 0$<br>Gradient $< 0$ | Graph above $x$-axis, $f'(x) > 0$<br>Graph below $x$-axis, $f'(x) < 0$ |
| **Rule of thumb:**<br>1. Always inspect the gradient of the $f(x)$, and deduce the magnitude<br>2. $f'(x)$ mirrors the behaviour of the gradient of $f(x)$. Slowly inspect important points such as turning point and asymptotes. | |

## Inequalities

| **Test-Point Method** | |
|---|---|
| Step 1 | Bring all equations to the same side. **NO CROSS MULTIPLICATION** |
| Step 2 | Reduce and simplify. Factorize the equations. If it is in fraction form, combine into a single fraction and factorize numerator and denominator completely. |
| Step 3 | Collect all critical points. Beware of critical points on denominator (they act as asymptote as well) |
| Step 4 | Use number line to gather all critical points and write the solution set. Beware of denominator's critical point as the root (see example below) |

| **Examples** | **Test-point** | **Solution** |
|---|---|---|
| $\mathrm{x}^2 - 4\mathrm{x} + 1 < 0$ |  | $x < 2 - \sqrt{3}$ *or* $x > 2 + \sqrt{3}$ |
| ***beware of repeated roots from a perfect square**<br>$(5-\mathrm{x})^5(3-\mathrm{x})(2\mathrm{x}-1)^6(2-\mathrm{x}) < 0$ |  | $2 < x < 3$ or $x > 5$ |
| $\frac{(x-1)(x+2)}{3x+4} \leq 0$ |  | $x \leq -2$ *or* $-\frac{4}{3} < x \leq 1$ |

**Modulus inequality**

$$|x| < a \leftrightarrow -a < x < a$$
$$|x| > a \leftrightarrow x < -a \text{ or } x > a$$

Note:

1. $|x - a| = |a - x|$
2. $x^2 = |x|^2$
3. $|x - a| < |x - b| \leftrightarrow (x - a)^2 < (x - b)^2$
   ***Since both sides are confirmed positive**

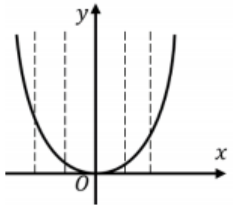
# FUNCTIONS

All functions = graphs. However not all graphs are functions. To test it, we use:

**Vertical Line Test**

For any vertical line $x = a$ where $a$ is real number, it will only cut $f(x)$ once.

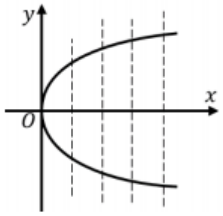
This applies for most graph, some well-known exceptions: circles and ellipses




$y = f(x) = x^2$

Vertical line only cuts at 1 point

**∴It is a function**




$y^2 = f(x) = x$

Vertical line cuts 2 points (more than one point)

**∴It is not a function**

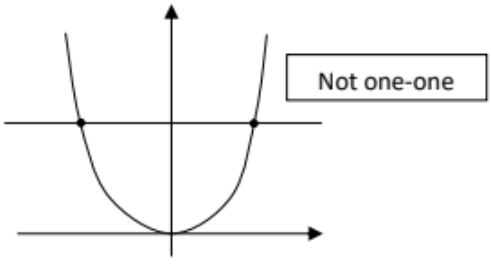
All functions that can be inversed is an one-one function. To test it, we use:

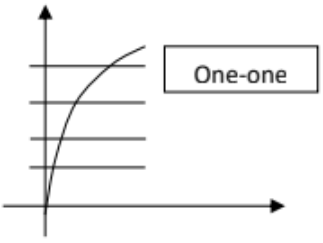
**Horizontal Line Test**

For any vertical line $y = b$ where $b$ is real number, it will only cut $f(x)$ once.

This applies to a few graphs (e.g.: $y = \frac{1}{x}$; $y = e^x$)

**Tips: Any graph that has a max/min point will never be an one-one function**

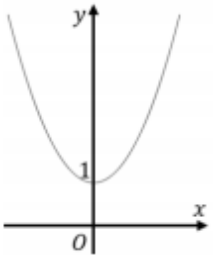
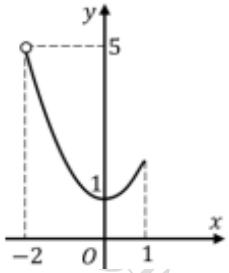


**Domain and Range**

Never draw a function without having it's domain. Domain is the of values of $x$ that the function takes.

Range is the set of "$y$-values" of the function after substituting all possible $x$-values

| | $\boldsymbol{f(x) = 1 + x^2}$ | $\boldsymbol{f(x) = 1 + x^2, -2 < x \leq 1}$ |
|---|---|---|
| Graph |   |   |
| Domain | $D_f: x \in (-\infty, \infty)$ or $x \in \mathbb{R}$ | $D_g: -2 < x \leq 1$ or $x \in (-2,1]$ |
| Range | $R_f: y \geq 1$ or $y \in [1, \infty)$ | $R_g: 1 \leq y < 5$ or $y \in [1,5)$ |

**Inverse Functions**

1. Inverse functions $f^{-1}(x)$ exist if and only if it is a one-one function $f(x)$
2. $f(x)$ and $f^{-1}(x)$ are symmetrical to $y = x$. They are reflection on $y = x$
3. To find their intersection, we can let $f(x) = x$ or $f^{-1}(x) = x$
4. $D_f = R_{f^{-1}} \ and \ R_f = D_{f^{-1}}$
5. Finding inverse usually requires completing the square. Ex:

$$y = x^2 + 2x - 9 \rightarrow y = (x+1)^2 - 10$$

Make $x$ as the subject.

$$(x+1)^2 = y + 10 \rightarrow x = \pm\sqrt{y+10} - 1 \rightarrow \boldsymbol{f^{-1}(x) = \pm\sqrt{x+10} - 1}$$

6. Have $f^{-1}(x) = +\sqrt{x+10} - 1$ for $x > -1$ (as $x = -1$ is the turning point)
7. Have $f^{-1}(x) = -\sqrt{x+10} - 1$ for $x < -1$

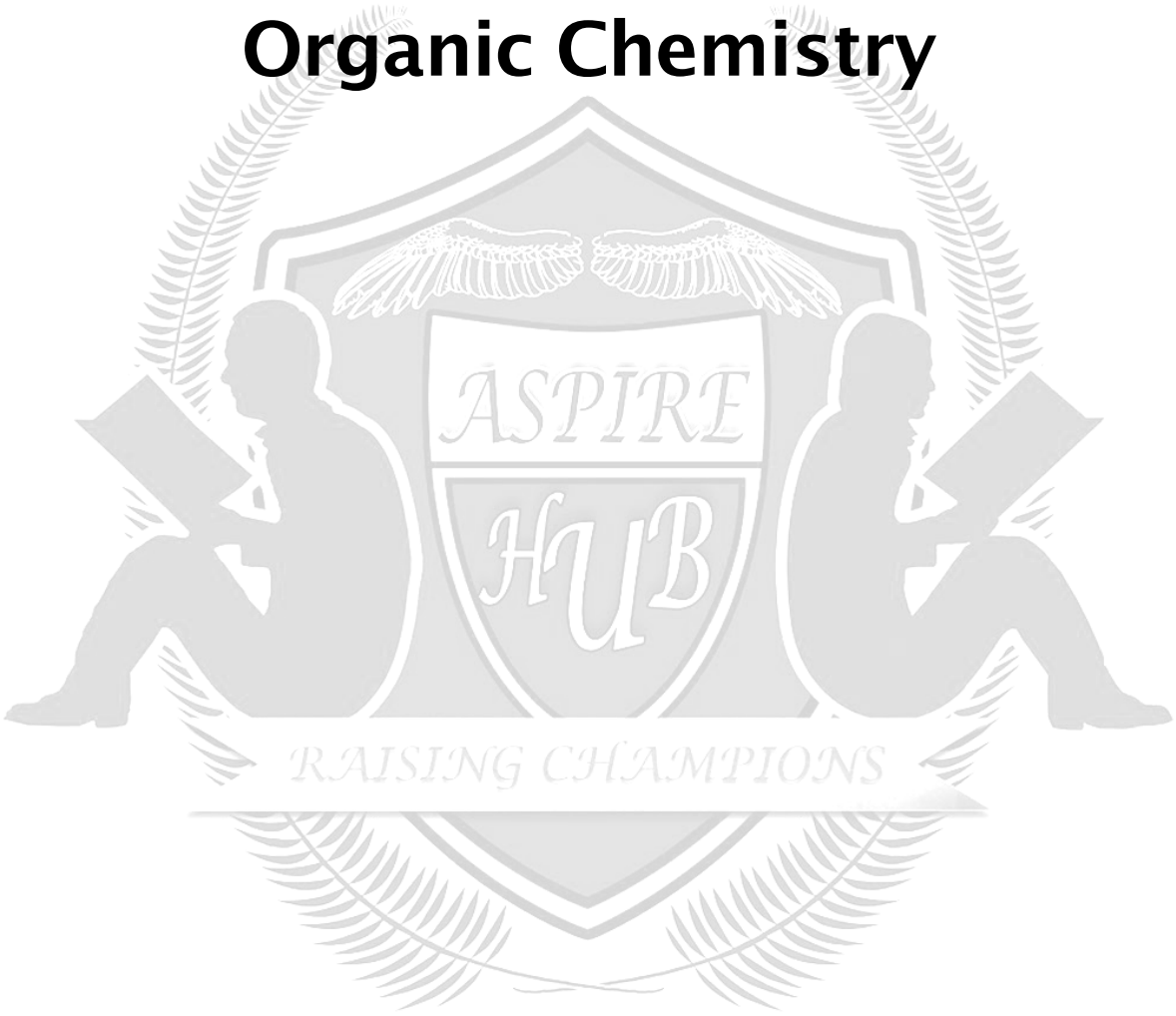
**Composite Function**

1. To have a composite function $fog$ to exists, make sure $R_g \subseteq D_f$
2. Composite function $fog$ has $D_{fg} = D_g$
3. Composite function $fog$ range can be determined by sketching $fog$, or by following these steps:
   - Finding $R_{fg}$, first find $R_g$
   - Use $R_g$ as the Domain of function $f(x)$
   - With this "new domain", find $R_f$ again. This will be the $R_{fg}$

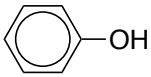
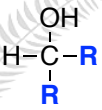
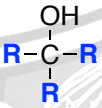
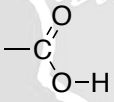
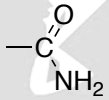
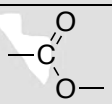
| | | |
|---|---|---|
| $f(x) = 3x + 1$ | $D_f = \mathbb{R}$ | $R_f = \mathbb{R}$ |
| $g(x) = x^2 + 2$ | $D_g = \mathbb{R}$ | $R_g = [2, \infty)$ |
| $fog(x) = 3(x^2 + 2) + 1$ | $D_{fg} = D_g = \mathbb{R}$ | $R_{fg} = [7, \infty)$ |
| $gof(x) = (3x + 1)^2 + 2$ | $D_{gf} = D_f = \mathbb{R}$ | $R_{fg} = [2, \infty)$ |

4. Composite of inverse: $fof^{-1}(x) = f^{-1}of(x) = x$. That is, whenever a function is does a composite to its own inverse, the result will be $y = x$

# Organic Chemistry



# NAMING AND FUNCTIONAL GROUP

| Compound | Functional Group | Compound | Functional Group |
|---|---|---|---|
| **Alkane** | Saturated Hydrocarbon / –C–C– bonds | **Acyl Chloride (-COC*l*)** |  |
| **Alkene** | Unsaturated Hydrocarbon / C=C | **Arene (Benzene Ring)** |  |
| **Alcohol (hydroxyl –OH)** | Primary Alcohol: R–**C**$H_2$–OH | **Phenol (Aromatic Alcohol)** |  |
| | Secondary Alcohol:  | **Halogenoalkane** | –X where X is a halogen |
| | Tertiary Alcohol:  | **Amine** | –$NH_2$ |
| **Carboxylic Acid (carboxyl –COOH)** |  | **Amino Acid** |  |
| **Aldehyde (–CHO)** NOT (–COH)/ **Ketone(–CO–)** |  | **Amide** |  |
| **Ester (–COO–)** |  | **Nitrile** | —C≡N |

Name of compound comprises of 3 portions:

**Prefix/es – Root/Stem – Suffix**

***Suffix*** – depends on a functional group of the organic compound.

High priority ↑ Low priority

| Functional Group | Suffix |
|---|---|
| –COOH group (carboxylic Acid) | -oic acid |
| –COO– group (ester) along the chain | -oate |
| –COC*l* group (acyl chloride) end of chain | -oyl chloride |
| –$CONH_2$ group (amide) along the chain | -amide |
| –C≡N group (nitrile) end of chain | -nitrile |
| –CHO group (aldehyde) on end of chain | -al |
| –CO– group (ketone) along the chain | -one |
| –OH group (Alcohol) | -ol |
| –$NH_2$ group (amine) along the chain | -amine |
| C=C group (alkene) | -ene |
| Alkane | -ane |

**Root/stem** – depends on number of carbon.

1 = meth-
2 = eth-
3 = prop-
4 = but-
5 = pent-
6 = hex-
7 = hept-
8 = oct-
9 = non-
10 = dec-

**Prefix** – used to represent other functional groups that are not being used as the principal (main) functional group.

| | | |
|---|---|---|
| **COOH** | Carboxy | 2 = di- |
| **OH** | Hydroxy | 3 = tri- |
| **$C_6H_5$** | Phenyl | 4 = tetra- |
| **C=O** | Oxo | |
| **$NH_2$** | Amino | |
| **$NO_2$** | Nitro | |
| **CN** | Cyano | |
| **$C_nH_{2n+1}$** | Alkyl | |
| **F** | Fluoro | |
| **C*l*** | Chloro | |
| **Br** | Bromo | |
| **I** | Iodo | |
| **OR** | Alkoxy | |

***Rule for Naming***

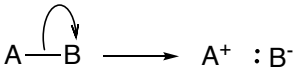
- Determine the longest continuous chain as the main functional group to be named as the *suffix*
- Lowest possible combination of number to be used for *prefixes*.
- *di, tri, tetra* to be used when prefix occurs more than once.
- If more than 1 prefixes are present, the naming is in accordance to alphabetical order, not considering the *di, tri, tetra*, etc.
- If there is ring formed the word **cyclo** is to be attached to the root. Example: *3-chlorocyclohex-2-enol*
- *Commas* are used to separate numbers and *hyphens* used to separate number from words. Example: *1-iodo-3,4-dimethylcyclopentene*
- Positional number can be omitted when they are redundant since there is only a possible structural formula. Example: *propene, butanoic acid.*

***HOMOLYTIC FISSION***

- Breaking of a covalent bond in which each bonded atom receives an electron, forming ***free radicals***.
- ***Half-head curly arrow is used to represent movement of one electron.***

***HETEROLYTIC FISSION***

- Breaking of a covalent bond in which more electronegative bonded atom takes both bonding electrons to form negative ion, while the other forms positive ion.
- ***Full-head curly arrow is used to represent movement of a pair of electrons.***



***Nucleophile***

- Species which have lone pair of electrons and are attracted to positively charged molecules or electron deficient site (δ+) in a molecule.
- e.g. $H_2O$, $OH^-$, $NH_3$

***Electrophile***

- Electron deficient species which are attracted to negatively charged molecules or electron rich site (δ-) in a molecule.
- e.g. $Br_2$, $H^+$, HC*l*

***Free radical***

- Species which have an unpaired electron.
  e.g. Br•

# ISOMERISM

**ISOMERISM**

**Structural**
- Same molecular formula
- Different structural formula i.e. different arrangement of atoms

**Stereoisomerism**
- Same molecular formula
- Same structural formula but different spatial arrangement of atom

**Chain** | **Positional** | **Functional Group** | **Geometric (cis-trans)** | **Optical isomerism**

### *CHAIN ISOMERISM*
Arises due to different arrangement of carbon chain.

e.g. $C_4H_{10}$

| | |
|---|---|
| C−C−C−C | n-butane |
| C−C−C<br>C | 2-methylpropane |

### *POSITIONAL ISOMERISM*
Arises due to different position of a functional group on a carbon chain or a ring chain.

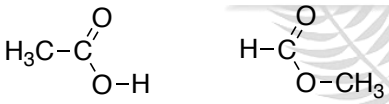
e.g. $C_3H_7Cl$

| | |
|---|---|
| C−C−C−Cl | 1-chloropropane |
| C−C−C<br>Cl | 2-chloropropane |

### *FUNCTIONAL GROUP ISOMERISM*
Arises due to different functional group.

e.g.

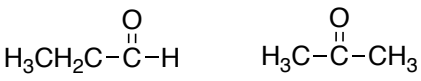
***Carboxylic acid and ester***



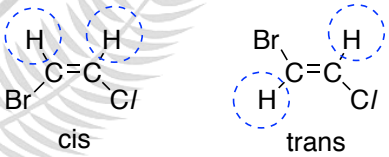
***Alcohol and ether***

$CH_3CH_2OH$ $H_3C-O-CH_3$

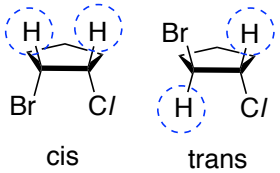
***Aldehyde and ketone***



### *GEOMETRIC ISOMERISM (CIS-TRANS)*
- Arises in *alkene* and *ring structure* due to restriction in the rotation around C=C by the presence of pi bond.
- There must be 2 different group of atoms attached on each C atom.



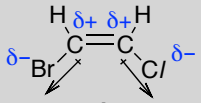

- In the ring structure, this arises due to *ring strain* that restricts rotation around C–C bond.



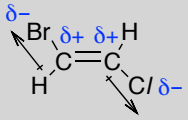
### *Physical property difference in cis- isomer and trans- isomer*

***Boiling point of cis- isomer is higher than trans- isomer***

- Dipole moments along the C=C bond ***do not cancel out in cis- isomer***. This will cause the molecule to be ***polar.***
- Dipole moments ***cancel out in trans- isomer***. This will cause the molecule to be ***non-polar.***



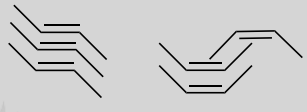
**polar**



**non-polar**

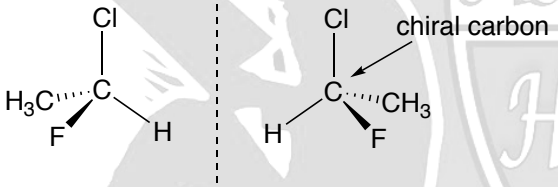
***Melting point of cis- isomer is lower than trans- isomer***

- Cis- isomer is ***not linear*** and thus will form more poorly-packed crystalline lattice when it solidifies.
- Trans- isomer is more stable than cis- isomer since the alkyl groups are on the opposite side. Its linear shape causes ***more efficient crystal lattice and packing of molecules*** that gives ***stronger intermolecular forces***.


**trans- packing** **cis- packing**

### OPTICAL ISOMERISM

- compounds that have same molecular and structural formula but ***the isomers are mirror image of each other and they are non-superimposable.***




- ***Chiral carbon*** is carbon with 4 different substituent.
- Each optical isomer (enantiomer) will rotate plane polarised light in opposite direction.
- ***Optically active*** compounds display ability to rotate plane polarised light.
- ***Racemic mixture*** is a mixture of the optical isomers in equal proportion. This solution is optically inactive because the optical rotation get cancelled out.

### *Maximum no of stereoisomer (geometric and optical isomers)*

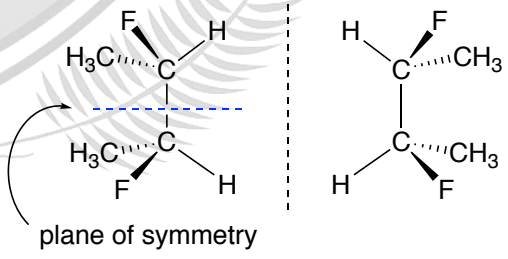
$$\max amount = 2^{m+n}$$

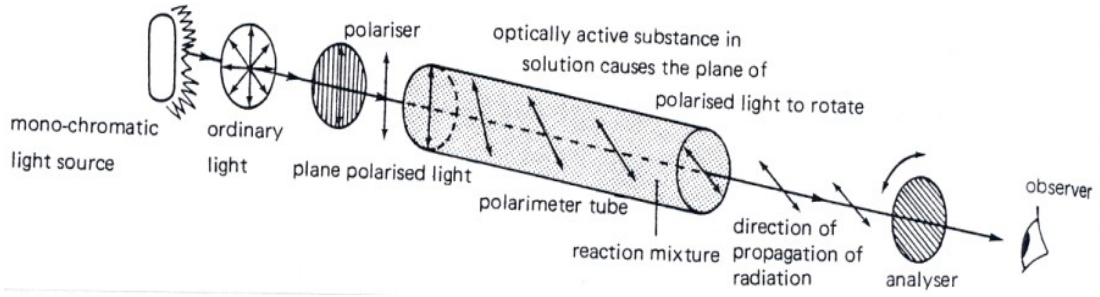
*m = no of chiral carbon*
*n = no of C=C bond capable of cis-trans*

***Diastereomers***, is stereoisomers which are not mirror image of each other.

### *Meso compound*

- A compound that contain ***internal plane of symmetry*** and is ***optically inactive.***
- Even though there are presences of chiral carbons, ***the mirror image of its compound is superimposable***.



# TYPE OF REACTIONS

***Substitution***
Involves ***replacing*** an atom (or group of atoms) by another atom (group of atoms)
e.g.
$C_2H_5Cl + OH^- \rightarrow C_2H_5OH + Cl^-$

***Addition***
Involves two molecules joining to form a ***single molecule*** without loss of any atoms.
e.g.
$Br_2 + CH_2=CH_2 \rightarrow BrCH_2CH_2Br$

***Elimination***
Involves the ***removal of a small molecule***, like water or HX, from adjacent carbon atoms.
e.g.
$C_2H_5OH \rightarrow CH_2=CH_2 + H_2O$

***Condensation***
Involves ***two molecules joining*** to form a big molecule with ***removal of small molecule*** like water.
e.g.
$CH_3COOH + CH_3CH_2OH \rightarrow CH_3COOCH_2CH_3 + H_2O$

***Hydrolysis***
Involves breaking a covalent bond by reaction with ***water.***
e.g.
$CH_3COOCH_2CH_3 + H_2O \rightarrow CH_3COOH + CH_3CH_2OH$

***Oxidation***
Involves addition of oxygen or removal of hydrogen by using oxidising agent.
e.g.
$CH_3CH_2OH + 2\,[O] \rightarrow CH_3COOH + H_2O$

***Reduction***
Involves addition of hydrogen or removal of oxygen by using reducing agent.
e.g.
$CH_3CHO + 2\,[H] \rightarrow CH_3CH_2OH$

# ALKANES

| | |
|---|---|
| **General formula** | $C_nH_{2n+2}$ |
| **Type of molecule** | Saturated |
| **Melting point boiling point** | Alkanes are ***non-polar*** molecules. Low m.p. and b.p. are due to ***weak instantaneous dipole – induced dipole*** that requires less amount of energy to overcome. |
| **Electrical conductivity** | Poor |
| **Solubility in water** | Insoluble, due to ***unfavourable interaction*** that releases ***insufficient energy*** to overcome hydrogen bonding in water. |
| **Unreactivity** | **Strong C – H bond** that requires large amount of energy to break. ***Low electronegativity difference*** between C and H, causing the bond to be non-polar and unreactive. |

***Reactions of Alkanes***

***Combustion***

- In the presence of excess oxygen, alkanes will burn to produce carbon dioxide and water.
- In the presence of limited oxygen, alkanes will burn to produce carbon monoxide and water.

***Cracking***

- Done in moderate temperature 450–500 °C with $SiO_2$ or $Al_2O_3$.
- This produces smaller alkane + alkene + hydrogen.

***Substitution Reaction (Free Radical)***

- ***Condition***: presence of UV light.
- Limited amount of halogen can be used to increase the yield of *mono-substituted product.*

## Free Radical Substitution Mechanism

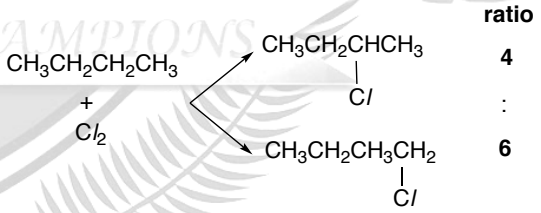
$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$

| | |
|---|---|
| **Initiation** | $Cl_2 \rightarrow 2Cl\bullet$ |
| **Propagation** | *Monosubtitution*<br>$CH_4 + \mathbf{Cl\bullet} \rightarrow \bullet CH_3 + HCl$<br>$\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + \mathbf{Cl\bullet}$<br>*Disubstitution*<br>$CH_3Cl + \mathbf{Cl\bullet} \rightarrow \bullet CH_2Cl + HCl$<br>$\bullet CH_2Cl + Cl_2 \rightarrow CH_2Cl_2 + \mathbf{Cl\bullet}$<br>*Trisubstitution*<br>$CH_2Cl_2 + \mathbf{Cl\bullet} \rightarrow \bullet CHCl_2 + HCl$<br>$\bullet CHCl_2 + Cl_2 \rightarrow CHCl_3 + \mathbf{Cl\bullet}$ |
| **Termination** | $\mathbf{Cl\bullet} + \mathbf{Cl\bullet} \rightarrow Cl_2$<br>$\bullet CH_3 + \mathbf{Cl\bullet} \rightarrow CH_3Cl$<br>$\bullet CH_3 + \bullet CH_3 \rightarrow CH_3CH_3$<br>$\bullet CH_2Cl + \mathbf{Cl\bullet} \rightarrow CH_2Cl_2$<br>$\bullet CHCl_2 + \mathbf{Cl\bullet} \rightarrow CHCl_3$ |

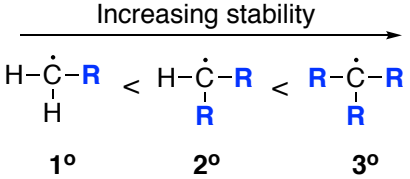
***Proportion of Product***

Depends on:

- ***Number of hydrogen atoms*** that can be substituted to form respective isomers.




- ***Stability of radical formed.*** More substituted radical is more stable due to electron donating (R –) alkyl group that can increase the electron density of the radical carbon by inductive effect.



# Economics

# LIST OF TOPICS FOR ECONOMICS ESSAYS

## Topic: Demand and Supply and Elasticity

**1** Organic food such as fresh fruits, vegetables and dairy products is grown without synthetic pesticides, chemical fertilizers or genetically modified seeds. 2015 was a year of significant growth for the organic food industry despite the continued struggle to meet the seemingly unquenchable consumer demand. There was also an increase in the number of farmers converting to organic farming over time.

Discuss the demand and supply factors that determine the output of organic food and evaluate which is the most important factor. **[25]**

## Topic: Market Failure

**2** To view the largest public display of Southeast Asian art at the National Gallery, non-Singaporeans have to pay $20 for standard tickets, while Singaporeans and permanent residents enjoy free entry.

**(a)** Distinguish between public good and merit good, and consider which category, museums like National Gallery, should be placed under. **[10]**

**(b)** Discuss whether the Singapore government should partially subsidise or provide free entry to museums like National Gallery as a way to achieve efficient allocation of resources. **[15]**

## Topic: Firms & Decisions / Market Structure

**3** To increase profits, firms may adopt strategies like price discrimination.

**(a)** Explain what is meant by price discrimination and the conditions necessary for it to be successful. **[10]**

**(b)** Discuss whether a firm's strategies to increase profits come at the expense of consumers' welfare. **[15]**

## Topic: Macroeconomics – Deflation & Interest Rate Policy

**4** **(a)** Explain the causes of deflation **[10]**

**(b)** Discuss whether the use of interest rates to address deflation is appropriate **[15]**

## Topic: International Trade & Globalisation

**5** Economists have warned that the rising tide of protectionism would threaten to derail the global economic recovery and advised governments to consider the benefits they have accrued from cross border trade.

Explain how engaging in free trade can benefit all countries and discuss whether the decision to introduce protectionist measures can ever be justified during a period of global economic recession. **[25]**

# SAMPLE ESSAY (DEMAND & SUPPLY & ELASTICITY)

**Applicable to H1 & H2 Economics**

**1** Organic food such as fresh fruits, vegetables and dairy products is grown without synthetic pesticides, chemical fertilizers or genetically modified seeds. 2015 was a year of significant growth for the organic food industry despite the continued struggle to meet the seemingly unquenchable consumer demand. There was also an increase in the number of farmers converting to organic farming over time.

Discuss the demand and supply factors that determine the output of organic food and evaluate which is the most important factor. **[25]**

***INTRODUCTION***

*In the farming industry, organic produce has become such an appetite for consumers to the point where the demand cannot be met due to a huge shortage of growers. Producers have responded to this growing demand by making the transition to certified organic food production.*

*Market equilibrium occurs when buyers and sellers come together and exchange at a mutually agreeable price and quantity. When the market is in equilibrium, there is no tendency for the price or the quantity exchanged (that is, the quantity bought and sold) to change as quantity demanded equals to the quantity supplied. Demand and supply in the free market will determine the equilibrium output. Hence, changes in the demand and supply will impact the market equilibrium.*

*The factors which determine the output of organic food are technological advancements and economies of scale which affect supply as well as factors such as tastes and preferences, and income level that influence demand.*

***BODY***

*Selecting food is one of the most common activities that consumers pursue many times each day. But this selection requires taking into account different factors (e.g. price and taste) and may involve a complicated decision-making process in order to satisfy these different factors.*

***Demand factor #1: Although the organic food sector comprises only a small percent of all food sales, the perceived environmental and health benefits of organic food have received increasing recognition and broader acceptance among consumers, hence a shift in taste and preference from non-organic food to organic food.***

*As the technology advances, people have easier and more convenient access to Internet and social media to find out more information about the enhanced health benefits of consuming organic food. Furthermore, since society has been adopting health-conscious eating habits and government has been promoting healthy lifestyle, the demand for organic food has only been steadily growing. In the minds of consumers, this trend of "eat good, feel good, look good" is convincing and rapidly growing as it has greatly contributed to why the majority of consumers are choosing organic. Environmentally conscious consumers are willing to pay a much higher price for sustainable products such as organic and locally-produced foods as ethical considerations are becoming important factors in their decision making process. Rise in demand for organic food. Hence, rightward shift of DD curve from DD0 to DD1.*

*Ceteris paribus, at the original price of the organic food $0P_0$, there is now a shortage of the good Q0Q2. The resulting shortage causes the price of the organic food to increase. As the price of the organic food*

*increases, its quantity demanded falls while the quantity supplied increases. These changes are illustrated by a movement up the demand curve D1 and a movement up the supply curve S0 respectively.*

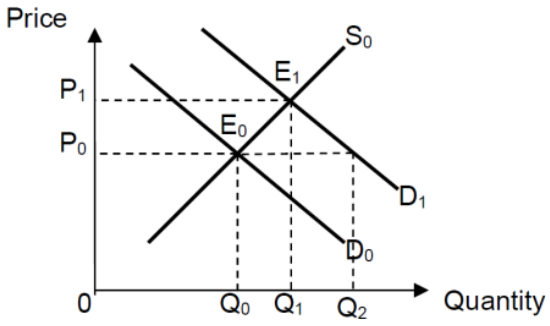



***Figure A***: *Market for organic food*

*Link: Price will continue to rise until the market is in equilibrium at price 0P1 and there is a rise in equilibrium output of 0Q1 of organic food being traded.*

***Demand factor #2: The global economic growth in the last decade contributed to a rise in demand for organic food.***

*Since organic food is considered a luxury good, any change in consumer income directly affects the percent change in demand, which will constitute how much consumers are willing and able to spend. If the amount of disposable income increases within consumers, they will feel more confident and compelled to spend those extra dollars towards better quality luxury goods, in this case organic foods. Due to the relatively more rapid growth in emerging markets and developing economies such as India and Philippines, as the income increases, consumers with higher purchasing power, shift their purchases away from higher quantities of food and into higher quality food. This simple analysis of the relationship between income and consumption is crucial for understanding and/or forecasting the likely future of the organic food industry.*

*Link: As income levels of consumers increases, consumers are very likely to purchase more quantity of organic products.*

***Evaluation of demand factors: Income growth, and the high standard of living that is enjoyed in the high-income nations of the world, is likely to be the single most important determinant of organic food consumption.***

*Because any perceived benefits, no matter how small, become affordable to wealthy consumers. Price premiums also become inconsequential to individuals and families with high incomes. As per capita incomes rise, we can expect a shift into organic food. An important implication of this is that low-income individuals in the USA, and low-income nations will be less interested in organic food, if it is more expensive than conventional food. For individuals and nations with low level so purchasing power, the perceived benefits of organic food are unlikely to outweigh the lower prices of conventional food. As incomes increase above subsistence levels, health issues shift from a lack of food and starvation to healthy diets and nutrition. Those who can afford it will purchase products that are perceived to be healthy, including organic food, even if the purchase price is considerably higher than conventional food.*

*Link: To summarize, market information about the benefits and costs of consuming organic and nonorganic foods will determine the future market shear of organic food in the food and beverage industry.*

***Using PES to justify demand factors*: The price elasticity of supply for organic food is likely to be less than one and hence, the rise in demand due to the 2 factors analysed earlier will likely lead to a mild rise in equilibrium output.**

*Although retailers have been flocking to the industry to capture the customers' high willingness to pay, farmers have not followed suit. Despite the opportunity to fetch higher prices for their products, farmers have been slow to convert to organics. One reason is the high transition costs (barrier to entry) to be labelled a certified organic producer. In order to be titled a certified organic grower, one must follow and go through a three-year transition period in compliance with organic restrictions and requirements. During this time period farmers experience much lower crop yields making their costs surge; a primary element for which growers won't go organic. Also, the benefits that come with organic growing such as receiving higher and premium prices for those organic products are not included in this 36-month process, yet another hindrance for farmers to transition to become certified organic producers. Additionally, organic farm operations are subject to added fees and regulations.*

*Organic production practices are often management-intensive, requiring greater managerial time, skill, and decision making. Organic certification requirements can also require that a farmer not use chemicals or synthetic fertilizers for three years prior to the land becoming available for organic food production. Thus, some of the transition costs are incurred prior to reaping the benefits of organic conversion. Hence, the supply of organic food is price inelastic. Farmers are not able to respond easily to a rise in a demand and price by releasing the stocks into the market for sale.*

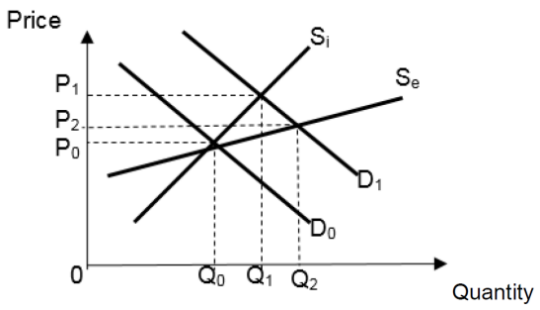



***Figure B**: Market for organic food*

*Link: Hence, as seen in the figure above, with the same rise in demand, the extent of rise in equilibrium output for organic food is smaller from Q0 to Q1 rather than from Q0 to Q2.*

***Supply factor #1*: Rapid technological advancement can change the outlook of organic food production.**

*The technology of organic food production is changing rapidly, as producers discover more efficient production processes that result in larger quantities and higher qualities of organic food produced at lower costs. Similarly, a cost-saving technological or regulatory change in the processing, transportation, packaging, marketing, advertising, or certification of organic food will also result in larger quantities produced by profit-motivated suppliers.*

***Supply factor #2*: Reaping of more economies of scale may change the outlook of organic food production.**

*As the fledgling organic food industry develops, it will capture economies to scale associated with the growth and development of organic food markets. An example is marketing economies. A large firm can capitalise on its bargaining power to buy its inputs in bulk at favourable rates. Similarly, the organic food of the firm can also be sold in bulk at reduced distribution costs too. For instance, it is more cost efficient for a large firm to transport large quantities using a large truck instead of several small vans. Large firms can also afford to advertise organic food in the national press and other forms of media. Although the advertising expenditure may be substantial, the advertising average cost may be lower than that of a smaller firm because cost of advertising is spread over the larger output level.*

*Specifically, as the infrastructure and institutions for organic food production, processing, and distribution become larger and more established, the per-unit cost of organic food falls, hence rightward shift of the supply curve from S0 to S1*

*Ceteris paribus, at the initial price 0P0, a surplus of Q0Q2 arises and this surplus exerts a downward pressure on price. Producers lower the price to get rid of their excess stock. As price falls, producers will reduce their quantity supplied of the good as shown by a movement along the supply curve. Consumers increase their quantity demanded of the good as illustrated by a movement along the demand curve D0.*

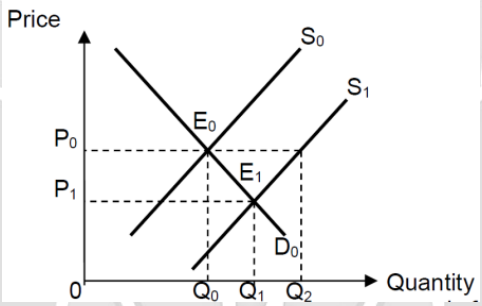



***Figure C**: Market for organic food*

*Link: Price will continue to fall until a new market equilibrium is established at point E1. The new equilibrium output of 0Q1 is higher than before the increase in supply.*

***Using PED to justify supply factors*: The price elasticity of demand for organic food is likely to be less than one and hence, the rise in supply due to the 2 factors analysed earlier will likely lead to a mild rise in equilibrium output.**

*Individuals who are committed to the ideals and lifestyle associated with organic food, OR who have high incomes, and are unaware or insensitive to price changes are unlikely to discontinue purchasing organic food. The first group is very unlikely to alter organic food purchases based on price movements, due to strong convictions about the complex interactions between agricultural chemicals, human health, and the environment. The second group of consumers does not alter consumption habits when prices of organic food change, simply because they spend a very small fraction of their income on food. As a result, price increases are unimportant to these individuals, and consumption decisions are unlikely to be affected by price  demand for organic food for these groups of consumers is price inelastic. This means that a rise in price of organic food will lead to a less than proportionate fall in quantity demanded of organic food, ceteris paribus.*

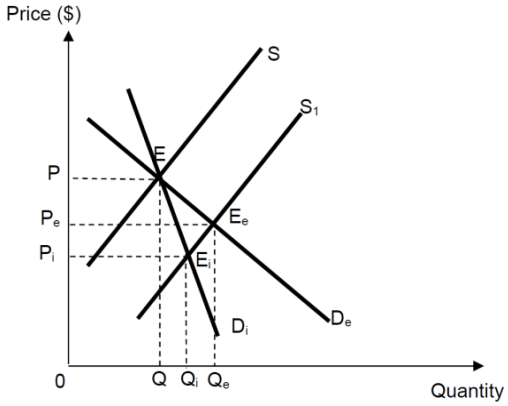



***Figure D**: Market for organic food*

*Link: Hence, as seen in the figure above, with the same rise in supply, the extent of rise in equilibrium output for organic food is smaller from Q0 to Qi rather than from Q0 to Qe.*

***SYNTHESIS***

*The conclusion is the cost efficiency factor (supply) is more important to determine the output of organic food in the **short run**. This is because the switching costs are much higher for farmers: regulations, three years of fallow ground, uncertain yields. The price they receive for a single unit of an organic product, therefore, is less valuable if it comes with greater risk and uncertainty. The organic market can only grow as far as farmers are willing to start growing organics.*

*However, the income factor (demand) will be more important to determine the output of organic food in the **long run** because demand for organic food is income elastic. As the affluence level increases, the demand for organic food will increase significantly. Luxury consumer goods such as organic food will continue to replace necessities, as high-income consumers can afford to pay for product attributes that are perceived to be healthy or good for the environment. As a result, many agricultural producers have found organic production practices to be a profitable alternative to conventional crops. Furthermore, though transition costs are high, the cost advantages of eliminating chemical and fertilizer bills, together with crop rotation advantages can contribute to net returns. Therefore, we may see a potential growth of the organic food market.*

***CONCLUSION***

*Consumers' interest in organic food has exhibited continued growth for the past two decades, which has attracted entrepreneurs and corporations seeing a big potential for this industry. This led to the creation of standards and regulations to guide the organic food industry. There are clear challenges on both demand and supply sides. Consumers are becoming more sophisticated in their purchasing decisions of organic food as they become more educated and affluent, and companies are focusing on supply chain management in order to ensure high quality, traceability, and supply continuity. The future extent of the increment in organic food output will depend on the market forces (market value).*