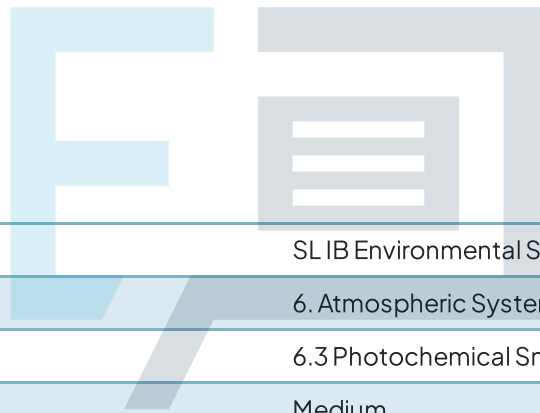




# 6.3 Photochemical Smog

## Mark Schemes



Course	SL IB Environmental Systems & Societies (ESS)
Section	6. Atmospheric Systems & Societies
Topic	6.3 Photochemical Smog
Difficulty	Medium

# Exam Papers Practice

To be used by all students preparing for  
SL IB Environmental Systems & Societies (ESS)  
Students of other boards may also find this useful

1

Indicative Content
<p>The processes through which the combustion of fossil fuels contributes to the formation of photochemical smog include:</p> <p>Any <b>three</b> from the following:</p> <ul style="list-style-type: none"> <li>• Fossil fuels undergo combustion / are burned, releasing nitrogen monoxide (NO) / nitrogen oxides (NO<sub>x</sub>) in vehicle emissions; [1 mark]</li> <li>• These pollutants / nitrogen oxides are released into the atmosphere and can be transported over a wide area. [1 mark]</li> <li>• In the presence of sunlight...; [1 mark]</li> <li>• ...these pollutants / nitrogen oxides interact with volatile organic compounds (VOCs) / peroxyacyl nitrates (PANs)...; [1 mark]</li> <li>• ...leading to the production of (tropospheric) ozone (contributing to smog formation); [1 mark]</li> <li>• Urban/developed areas/cities in valleys/basins/surrounded by mountains are vulnerable to (photochemical) smog because pollutants cannot disperse/spread out; [1 mark]</li> <li>• The formation of photochemical smog is particularly problematic in urban areas with high vehicle emissions / temperature inversions / stagnant air conditions / lack of wind; [1 mark]</li> </ul>

2

Indicative Content	Commentary
<p>Effects of tropospheric ozone include:</p> <p>Any <b>four</b> from the following:</p> <ul style="list-style-type: none"> <li>• Reduces growth/productivity of plants/forests/vegetation <b>OR</b> decreased crop yields (due to damage); [1 mark]</li> </ul>	<p>You need to give specific effects</p> <p>For example, giving 'negative effect on health' as an answer would not gain a mark</p>

<ul style="list-style-type: none"> <li>• Damages fabrics / rubber materials / building materials <b>OR</b> reacts with plastic/rubber causing it to perish/ become hard/inflexible; [1 mark]</li> <li>• Causes irritation/soreness in eyes / eye diseases; [1 mark]</li> <li>• May cause breathing difficulties <b>OR</b> irritates lungs / respiratory system / causes respiratory disease/lung cancer; [1 mark]</li> <li>• May increase the risk of infection <b>OR</b> depresses immune system <b>OR</b> smog reduces the immune system of humans/animals / makes them more susceptible to diseases; [1 mark]</li> <li>• Increases (local) temperature / adds to the urban heat island / ozone acts as a greenhouse gas (at ground level), contributing to warming/higher temperatures; [1 mark]</li> <li>• Reduces air quality/visibility/ambience within urban areas; [1 mark]</li> </ul>	
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3a

Indicative Content	Commentary
<p>Possible reasons for the overall trends in global tropospheric ozone levels include:</p> <p>Any <b>four</b> from the following:</p>	<p><i>You would only gain a maximum of three marks if you only discuss the increase or decrease, or if you failed to clearly identify either the increase or decrease</i></p>

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In first few years / 1989–1991, the increase was/may have been due to:

- An increase in population / car ownership/use / fossil fuel combustion/use; [1 mark]
- An increase in industrialisation / oil /fossil fuel industry; [1 mark]
- A lack of political awareness surrounding the issue/dangers; [1 mark]
- A lack of funding to address the issue; [1 mark]

*It is important to look for trends in the data*

*The spike from 1989–1991, although brief, still represents a significant trend in this dataset*

From around 1991 onwards, the (steady/overall) decrease was/may have been due to:

- Developments/improvements in technology e.g. (greater) energy efficiency / hybrid cars / catalytic converters (in cars) / scrubbers (air pollution control devices that remove particulate matter / gases from industrial exhausts); [1 mark]
- The introduction of stricter monitoring/regulations of air quality control for industries / car manufacturers/owners; [1 mark]
- A (gradually/steady) switch to cleaner-burning/alternative energy sources; [1 mark]
- The introduction of green initiatives / education campaigns / lobbying of politicians to promote environmentally friendly alternatives e.g. public transport

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/ car-sharing / cycle-to-work schemes; [1 mark]

3b

Indicative Content	Commentary
<p>The average annual decrease in tropospheric ozone concentration (in parts per billion) between 1991 and 2010 can be calculated as follows:</p> <ul style="list-style-type: none"> <li>• <math>(70 - 30) \div 19</math> OR <math>40 \div 19</math>; [1 mark]</li> <li>• 2.1 / 2.11 (parts per billion per year); [1 mark]</li> </ul>	<p><i>A correct final answer would still gain two marks even if you don't show your working</i></p> <p><i>If you give the answer as a negative value (i.e. -2.1 or -2.11), you would still gain the marks here</i></p>

4

#### Indicative Content

Air pollution management strategies that can be used to reduce tropospheric ozone and photochemical smog include:

Any **four** from the following:

- Implementation of stricter emission standards/regulations for vehicles/industrial sources to reduce nitrogen oxides (NO<sub>x</sub>) and emissions of volatile organic compounds (VOCs) **OR** implementation of industrial best practices/technologies that minimise emissions of NO<sub>x</sub>/VOCs during manufacturing processes e.g. low-VOC paints and solvents; [1 mark]
- Promotion of cleaner transportation options e.g. electric vehicles / hybrid cars / public transportation / car-pooling / reduced person vehicle usage to decrease vehicle emissions **OR** further developments/improvements in technology e.g. (greater) energy efficiency / hybrid cars / catalytic converters (in cars) / scrubbers (air



- pollution control devices that remove particulate matter / gases from industrial exhausts); [1 mark]
- Adoption of green spaces / urban forestry / vegetation in urban planning to act as sinks for pollutants / to enhance air quality through natural processes; [1 mark]
  - Implementation of vehicle inspection/maintenance programs to ensure proper functioning of emission control systems / to reduce the release of pollutants; [1 mark]
  - Introduction of 'ozone action days' in cities with severe pollution problems e.g. alerts to encourage the public to reduce activities that contribute to ozone formation on high pollution days; [1 mark]
  - Implementation of regional/national air quality management plans that address specific sources of pollution / coordinate efforts among different sectors; [1 mark]
  - Promotion of renewable energy sources / reduction of fossil fuel combustion to lower emissions of ozone precursor chemicals;
  - Public education/awareness campaigns about the causes/effects of tropospheric ozone/photochemical smog, encouraging behaviour changes to reduce emissions **OR** the introduction of green initiatives / education campaigns / lobbying of politicians to promote environmentally friendly alternatives e.g. public transport / car-sharing / cycle-to-work schemes; [1 mark]
  - Development of advanced air quality monitoring systems to accurately track/predict pollution levels / to inform decision-making for pollution management strategies; [1 mark]