STUDENT NOTES

STUDY OBJECTIVES

Underline/highlight the answers to these *additional* questions as you read:

- Why is oxygen so important to the body?
- When can oxygen be toxic?
- What are the causes, signs and symptoms of hypoxia and hypoxic hypoxia?
- What is the significance of respiratory noises and lower airways diseases?
- What are the signs and symptoms of Chronic Obstructed Airways Diseases (COAD) and Chronic Airways Lesions (CAL) and how do you manage COAD/CAL casualties?
- What are the equipment components of an oxygen system?
- How do you estimate the duration of an oxygen supply?
- Which oxygen delivery masks are appropriate for trained lay-level Emergency Responders to use?
- What are the following oxygen delivery devices – oropharyngeal / naso-pharyngeal airways - and what is their purpose?
- What are the precautions for safe storage and handling of oxygen cylinders?
- What regular maintenance is required for an emergency oxygen system?
- Which local standards and regulatory requirements govern emergency oxygen use?

EMERGENCY OXYGEN USE

Why is oxygen so important to the body?

First aid with emergency oxygen is useful or necessary as a treatment for many injuries, diseases and intoxications that interfere with normal oxygenation of the blood or tissues. A lack of or reduction in oxygen in the bloodstream can and often is life-threatening. Oxygen therapy is the treatment that provides extra oxygen to the tissues of the body through the lungs and is usually delivered by a face mask, but nasal prongs can also be used.

When can oxygen be toxic? - The chemical symbol for oxygen is O_2 and the oxygen partial pressure (ppO_2) at sea level is 0.21 bar. Breathing pure oxygen continually can be toxic, but only after many hours of exposure (generally greater than 11hours) or if there is an increase in the ppO_2 i.e. if the oxygen partial pressure is greater than 0.5bar.

The casualty will be in medical care, or the oxygen will be exhausted, long before toxicity is an issue.

What are the causes, signs and symptoms of hypoxia and hypoxic hypoxia?
Hypoxia is a condition in which there is an inadequate supply of oxygen in the body, possibly due to:

- inadequate oxygen transport
- an inability of the tissues to use oxygen
- a reduction in oxygen pressure in the lungs
- reduced gas exchange area
- lung disease

The major causes of hypoxia are those conditions that impair oxygen entering the body or its circulation throughout the body. Signs and symptoms of hypoxia include laboured breathing, lack of breathing, unresponsiveness, a feeling of air starvation, blue tissue colour.

Hypoxic hypoxia is a result of insufficient oxygen available to the lungs, e.g. a blocked airway or a drowning or a reduction in the partial pressure (high altitude above 3,000 metres (10,000 feet).

What is the significance of respiratory noises and lower airways diseases?
The respiratory tract is divided into two main segments:

- Upper respiratory tract: nose and nasal passages, sinuses, and throat or pharynx
- Lower respiratory tract: trachea, bronchi, bronchioles and lungs

Respiratory noises such as wheezing, shortness of breath, chest tightness and coughing are signs that there could be a lower airway disease such as asthma, emphysema or bronchitis. These diseases are not normally present in the scuba diving community.

> *Asthma reminder* - Those with asthma suffer from acutely sensitive and susceptible bronchial tubes. This can be caused by numerous factors including smoking, cold weather, infections and inhalants such as sea water. The presence of these elements can cause the bronchial tubes to narrow and therefore restrict air passages, a dangerous situation for a diver. Medication used for asthma attacks, commonly involve aerosol inhalers and severe attacks will often require the services of EMS.

Chronic Obstructed Airways Diseases (COAD) and Chronic Airways Lesions (CAL).
Alternative causes for hypoxia could be an airway obstruction or lung damage. Chronic Obstructed Airways Diseases (COAD) - also known as Chronic Obstructive Pulmonary Diseases (COPD) - are a collective term for a number of lung diseases that prevent the lungs from breathing properly. Two of the most common types are emphysema and chronic bronchitis; these often occur together.
Chronic Airway Lesions (CAL) are generally injuries from COADs as any process that damages tissues cause lesions. Lesions are any abnormal tissue found on or in an organism which has been damaged by disease or trauma. (*Lesion* is derived from the Latin word *laesio,* which means *injury*.)

What are the signs and symptoms of COAD/CAL? Because of such diseases, the body has difficulty transferring large amounts of oxygen and carbon dioxide between the blood stream and the lungs. The main symptoms of COAD are *dyspnea* (shortness of breath), which may be accompanied by wheezing, and a persistent cough with or without sputum production. Severe COAD could lead to *cyanosis* (bluish decolorisation, usually in the lips and fingers) caused by a lack of oxygen in the blood.

How do you manage COAD/CAL casualties? Extremely rarely, some people who suffer from COAD develop complications when provided with emergency oxygen. This is because our body is stimulated to breathe by the increasing amount of carbon dioxide in the lungs, and some COAD sufferers rely more on diminishing oxygen levels to stimulate taking a breath. Therefore, administering emergency oxygen to a COAD sufferer can lead to a reduction in breathing. However, emergency oxygen should not be withheld from someone who suffers from COAD who appears hypoxic. The benefits of administering oxygen are far greater than any detrimental effects. The best method of providing oxygen in this situation is via a nasal cannula.

EMERGENCY OXYGEN EQUIPMENT

What are the equipment components of an oxygen system?
Oxygen Cylinders. Medical oxygen is stored under pressure, generally from 150 to 160bar (approximately 15,000 to 16,000 kPa) in steel or aluminium cylinders. Cylinders are identified by:

- Australian standard pin index or bull nose valve for oxygen equipment
- Black cylinder with white collar
- The cylinders should be labelled ‘Medical Oxygen’
- Cylinders should have a yellow diamond, ‘Oxidizing Gas’ hazard label

Common cylinder capacities are:

'B' - 200 litres when full (standard 2 litre (lt) cylinder = uncommon)

'CH/C' – 470/490 litres when full (3 lt cylinder = most common size)

'D' – 1,640 litres when full (10ltr cylinder) – commonly seen in Doctors' surgeries

'G' – 8,300 litres when full (commonly found in hospitals)

Oxygen cylinders from different companies often hold slightly different quantities of gas. The most common size for administering oxygen in an emergency situation is the 'CH/C' cylinders. Fixed oxygen equipment normally use 'D' size or bigger cylinders. Cylinders should not be completely emptied of oxygen and should be changed when the pressure drops to around 10bar (1000kPa).

Oxygen Valves/Pressure Regulators. Oxygen is delivered through a valve to a regulating device (regulator) which reduces the pressure to a safe 390-400 kPa (approximately 3.9-4bar). These regulators fit onto cylinders valves with either a yoke and indexing pins, or a bull-nose fitting.

There are three regulators that are commonly used in lay-level emergency oxygen systems:

- *Simple constant flow* regulators deliver oxygen at 15 litres per minute (l/m).
- The *adjustable constant flow* regulator delivers oxygen at a constant but adjustable rate. Typically, these can be adjusted for flows from 0-15 or 0-25 lpm.
- *Multifunction regulators* have adjustable constant flow capability and are able to supply both constant flow and high pressure oxygen delivery devices, e.g. constant flow masks and/or Demand inhalator valves, or mechanical resuscitators i.e. Manually Triggered Resuscitator Valves and Bag-Valve-Mask (BVM). Full flow rates of oxygen are supplied directly to a demand valve in the case of a mechanical resuscitator and this is further reduced by these valves to a breathable level.

Flow meters and flow controllers of oxygen are varied by either a fixed flow outlet set between 3-8 litres per minute (lpm), or by an adjustable flow meter that delivers between 1-25 lpm. This is consistent with the requirements for supplementary oxygen administration.

- The regulator includes a *pressure gauge* that reads the cylinder pressure after the valve is opened. This gauge should be monitored so that the cylinder does not empty while delivering oxygen to a casualty.
- Adjustable constant flow regulators include a *flow meter*, which is set to control

the flow oxygen. Typical *flow meters* for emergency use can be set in click stop increments from 0.5 to 25 lpm.

- Other pressure compensated *flow meters* have a gauge with a rising ball instead of click stops. Adjust the flow so the ball indicated the desired flow rate. These need to be kept upright to indicate the right flow of oxygen.
- The Bourdon-gauge *flow meter* indicates the flow rate on a gauge instead of click stops. Adjust the flow to the desired rate on the gauge rather than using preset stops. These are more common on oxygen units for EMS providers than on emergency oxygen systems for lay-level Emergency Responders.

How do you estimate the duration of an oxygen supply?

To estimate how long an oxygen cylinder will provide oxygen to a casualty, divide the capacity of the cylinder in litres, by the expected consumption rate measured in litres per minute i.e. a full C size cylinder of 490 litres delivering a constant 10 lpm flow rate will last approximately 49 minutes.

Should the cylinder be less than full, the estimated duration can be determined by multiplying the estimated time by the current pressure then divide that by the pressure when full. For example, a full C size cylinder rated at 150bar when full which now only has 100bar:

- 49 minutes x 100 bar/150 bar = approximately 32 minutes (32.67)

When delivering oxygen via a constant flow mask, the following table outlines expected operating duration from a full 'C' cylinder (490 litres):

Flow Rate	Duration
15 lpm	32 Minutes
8 lpm	61 Minutes

Which emergency oxygen delivery masks are appropriate for trained lay-level Emergency Responders to use?

There are several types of delivery masks for oxygen use. All attach to the regulator's outlet to route oxygen through tubing or high pressure hoses to the casualty. The following are used by lay-level Emergency Responders:

A *nasal cannula* has two outlets that fit into the casualty's nostrils. It delivers an oxygen concentration of 40% to 50%. Nasal cannulas can be used by lay-level Emergency Responders to assist responsive casualties who feel uncomfortable wearing a mask or

holding a mask in place or in the case of a COAD/COPD casualty. (The casualty has to be responsive and able to consciously breathe through their nose.) Adult flow rates for nasal cannula are 2-6 lpm, 2-4 lpm for children and 1-2 lpm for infants.

A *simple mask* covers the nose and mouth which is held in place by a strap. Oxygen flows into the mask, which the casualty inhales with each breath. Openings in the mask allow air to enter as well because oxygen flow alone doesn't provide enough volume for each breath. It delivers an oxygen concentration of up to 60%.

Non-rebreather masks are similar to simple masks but make much better use of oxygen. *Non-rebreather masks* are the generally preferred masks for providing oxygen to responsive *and* unresponsive breathing casualties. The flow rate should be set at 15 lpm for an adult and 4-6 lpm for children. Remember to adjust the flow rate for casualty comfort; the bigger the casualty, the higher the setting.

Pocket masks
Demand inhalator valve

Manually triggered resuscitator valve – are masks with a *positive pressure* device or button, which allows trained operators to initiate the flow of oxygen at 'the touch of a button' to provide oxygen therapy to a non-breathing casualty.

A *Bag-Valve-Mask (BVM) device* consists of a facemask that covers the nose and mouth, a large self-inflating bag with a series of one-way valves to provide positive pressure ventilations.

- Oxygen or air flows into the self-inflating bag, which may also have a reservoir bag like a non-rebreather mask.
- The oxygen flow rate should be set between 10-15 lpm.
- With a reservoir bag, BVM's can provide 95-100% oxygen; without the reservoir bag, oxygen levels can drop to around 50%. Exhaled breath exits the mask via a one-way valve.

- BVM resuscitators can be cleaned and reused, or are disposable, therefore BVM's can be a cost-effective option to provide oxygen resuscitation.
- BVM's are connected to the barbed constant flow outlet on the oxygen regulator and can be used to provide rescue breaths if the oxygen supply is depleted.
- To optimise BVM performance, it is recommended that two people work together in the operation of the BVM equipment - one person to hold the facemask in place to ensure a good seal, and the other trained person squeezes the bag to provide rescue breaths for the casualty. If there is only one person, the rescuer should position himself at the top of the casualty's head so that he can easily see the chest rise and fall with each ventilation while maintaining a proper seal and open airway.
- Slow, gentle ventilations minimise the risk of gastric inflation and regurgitation. The masks are made of transparent material to allow detection of regurgitation.
- Bags for these systems come in three sizes - adult, paediatric and infant (paediatric and infant bags must include a 'pop-off' pressure relief valve); adult bags should not be used on children as over-inflation of the lungs is likely to occur.
- After training, repeated practice is required to maintain the skill level.

What are the following oxygen delivery devices - Oropharyngeal/nasopharyngeal airways – and what is their purpose?

- *Oropharyngeal airways* and *nasopharyngeal airways* are devices inserted into the mouth (oro) or nose (naso) to maintain an open airway. These do not provide oxygen, but assure an open airway. BVMs are generally used with oropharyngeal/nasopharyngeal airways and together, these devices are generally used by EMS professionals.

Some oxygen systems humidify the oxygen by routing it through a device with sterile water. These humidifier devices are not normally used by lay-level Emergency Responders as 'dry' oxygen is not considered a significant issue for short term exposures.

SAFETY CONSIDERATIONS

What are the precautions for safe storage and handling of oxygen cylinders?

Oxygen cylinders should be stored carefully and in accordance with relevant government regulations. Prior to storing cylinders, contact your company or

organisations Occupational Health & Safety (OHS) representative for direction and advice.

The safe storage and handling of oxygen cylinders is covered in local Codes of Practice addressing the storage and handling of dangerous goods and in Australian Standards AS4332-2004: The storage and handling of gases in cylinders.

The general rules and important points are summarised as follows:

- Cylinders should be kept cool, dry and under cover
- All cylinders should be kept in a secure but accessible area near the oxygen equipment
- Cylinders should be contained or secured to prevent movement and precautions should be taken to prevent them from falling over
- The storage area should be out of direct sunlight and away from heat
- The storage area should have the regulation signage
- There should be no naked flames or smoking allowed within 25 metres of stored oxygen cylinders
- Full and empty cylinders should be clearly marked and kept stored separately
- Empty cylinders should be returned for filling without delay

Please note:

- Used or empty cylinders should be treated with the same precautions as “full” cylinders, since residual hazards remain.
- Cylinders are subject to periodic testing, at least every 10 years.
- Check the last test date on the cylinder “collar”.

CARE AND MAINTENANCE

What regular maintenance is required for an emergency oxygen system?

Proper maintenance of emergency oxygen equipment is easy and necessary. There are very few user-serviceable components on emergency oxygen systems and each unit will have specific manufacture instructions, which should be consulted prior to cleaning the equipment. A two minute submersion in a common type of commercially available disinfectant (e.g. a solution of 70% alcohol with 0.5% chlorhexidine) is effective against a number of viruses and bacteria. The oxygen equipment should be cleaned prior to disinfecting.

Disposable Items:

- Examples of disposable items are non-rebreather masks, one-way valves for pocket masks and all plastic tubing.
- Replace disposable items before repacking a kit for storage.

Non disposable items:

- Thoroughly wash, disinfect and dry any non-disposable parts after use – including face masks from manikins
- Masks with an inflatable/inflated cuff should be replaced at the first sign of wear
- Spare O-rings or sealing washers should be stored with the equipment
- Most cases can be washed with non-fat based soap and water; however, plastic cases should not be cleaned with substances that adversely affect plastic.

LOCAL STANDARDS AND REGULATORY REQUIREMENTS

Which local standards and regulatory requirements govern emergency oxygen use?

Australian Resuscitation Council (ARC) Guideline 10.1.2 THE USE OF OXYGEN IN EMERGENCIES November 1993 (current):

- Safety precautions with oxygen
- Equipment familiarisation, assembly, disassembly and fault finding
- Responsibility for servicing of oxygen equipment
- Cleaning, disinfection and/or disposal of oxygen equipment components
- First aid conditions where oxygen may be of value
- The administration of oxygen to the spontaneously breathing victim, and mouth-to-mask resuscitation with supplemental oxygen

Annual revision courses with re-accreditation assessment and recertification are essential.

Medical Oxygen is *not* listed in the "Standards for the Uniform Scheduling of Drugs and Poisons" produced by the National Health and Medical Research Council. This means that in Australia, it can be obtained without a prescription, although some suppliers request that a current oxygen administration certificate is provided.

In relation to the periodic testing of oxygen cylinders, Australian Standard AS: 2030.1 covers 'The verification, filling, inspection, testing and maintenance of cylinders for storage and transport of compressed gases. Part 1: Cylinders for compressed gasses other than acetylene' states that the maximum interval for inspection is 10 years unless the cylinder or valve show evidence of irregular treatment or there is more than 500 fills per year.

Manufacturers of medical oxygen comply with the *Code of Good Manufacturing Practice for Therapeutic goods – Medicinal gases*. Medicinal gasses are regulated

under the *Therapeutic Goods Act 1989*, by the Therapeutic Goods Administration (TGA). The requirements of this Act include the licensing of the manufacturer of medicinal gas by the TGA. Medical oxygen cylinders are required to be filled at reputable medical oxygen filling stations and these stations comply with Australian Standard AS3848.1-1999 Filling of portable gas cylinders.
In Australia two well-known gas producers fillers are *BOC* and *Air Liquide*, however there may be others in your region.

In relation to recreational scuba diving and the use of oxygen administration as a first aid treatment, various Codes of Practice and regulations exist. Some examples are provided below, but they are by no means an exhaustive list.

In New South Wales, there are no prescriptive rules or regulations regarding the use or administration of oxygen for therapeutic purposes. Therefore, follow Australian Standards AS4005.1 Training and certification of recreational divers, Part 1: Minimum entry-level SCUBA Diving. This standard covers emergency first aid equipment and recommends that during all diver training activities there should be a competent person able to utilise suitable first aid supplies and an oxygen resuscitator for treating diver injuries. In relation to the administration of oxygen, the equipment should be able to provide as near as possible 100% oxygen to a breathing casualty and greater than 50% oxygen to a non-breathing casualty. First aid supplies and sufficient oxygen should be calculated dependant on the availability of the EMS and dive site location.

In Queensland, the "Compressed Air Recreational Diving & Recreational snorkelling" and the "Occupational Diving at Work Code of Practice" have requirements regarding the supply and equipment used for oxygen administration. The Codes of Practice states:

1.3 Health and safety control measures specific to compressed air recreational diving:

1.3.13 First aid and oxygen "An employer/self employed person/s should ensure:

f. a first aid kit is available at the dive site. The contents of this kit should be sufficient to cater for the injuries that may occur. Consideration also should be given to the number of divers and the nature and type of underwater diving which is being undertaken

g. a person on the surface at the dive site should hold current training in diving first aid including emergency oxygen administration (see section 1.2, diving first aid)

1.2 Diving first aid. A current qualification received for training in:

- first aid and emergency oxygen administration to injured scuba divers
- training in scuba accident management
- field clinical assessment.

h. an oxygen system capable of providing a spontaneously breathing person with an inspired oxygen concentration of as near as possible to 100%. The equipment shall also facilitate oxygen enriched artificial ventilation of a non-breathing person. The person/s administering the oxygen should have received training in the correct use of the system

i. oxygen equipment and oxygen levels are checked daily by a person who has received training to carry out the checks correctly. Any other maintenance of the oxygen system should be carried out by an authorised service agent

j. sufficient oxygen is available to supply the injured person, taking into account the location of the dive site and access to medical facilities.

In Western Australia, the "Diving and Snorkelling" Code of Practice 2003 contains requirements regarding the supply and equipment used for oxygen administration:

2.2 Emergency equipment and procedures. At each dive site, the employee should ensure that the following is available:

2.2.1 First aid Equipment and Kit as per Australian Standard 4005.1 (Minimum entry-level SCUBA diving).

2.2.1.1 - The kit should have sufficient resources for the situation, taking into account the number of people, the distance from medical assistance and the nature of likely first aid requirements.

2.2.1.2 - There should be a person at the dive site who is qualified in both dive first aid and able to administer as close as practical to 100 per cent oxygen.

2.2.1.3 - An oxygen system should be available at the site, or nearby, and be capable of delivering as close as practical to 100 per cent oxygen immediately to a person who is breathing spontaneously.

2.2.1.4 - All oxygen equipment and levels should be checked each day by a suitably trained person and the equipment maintained to standards by an appropriately qualified person.

2.2.1.5 - Sufficient oxygen should be available at all times, taking into account the distance to back up medical services.

2.2.2 *Rescues and emergencies:* One or more persons competent to operate the oxygen delivery system and capable of administering first aid should be available at each dive site.

ADMINISTER EMERGENCY OXYGEN SKILLS

The following outlines an additional skill you may learn as part of your PADI Asia Pacific Administer Emergency Oxygen course. Use this portion of your Student Notes if you practice this skill with your Instructor.

Bag-Valve-Mask (BVM) Use for a Non-breathing Casualty

Performance Requirement

Demonstrate how to use a Bag-Valve-Mask (BVM) on a non-breathing casualty by:

- Turning on the oxygen cylinder valve.
- Checking the safety valve to ensure it functions properly by blocking the oxygen outlet.
- Delivering the oxygen use statement.
- Self-testing the system.
- Opening the casualty's airway.
- Placing the mask on a casualty's face/head so it is comfortable, has a proper seal, and delivers a high concentration of emergency oxygen.
- Squeezing the bag to manually provide the casualty with oxygen and rescue breaths.

Value

Near drowning, DCI and other injuries or illnesses may cause a diver to stop breathing. In this case, you need to breathe for the diver and, if possible, provide them with supplemental emergency oxygen. For any casualty, Bag-Valve-Mask systems can provide a relatively simple, cheap and effective means to resuscitate a casualty with up to 100 percent oxygen. Learning how to use a Bag-Valve-Mask device can help you provide emergency oxygen to a non-breathing casualty. In addition, Bag-Valve-Masks can still be used if the emergency oxygen supply is depleted so their use is less exhausting than mouth-to-mouth resuscitation for the emergency oxygen provider.

Key Points

- Wash your hands prior to practice. Use gloves as appropriate.
- Clean BVM as per manufacturer's instructions or replace the BVM after each student's use.
- When helping a casualty always:
  - Remember to stop, think, then act (DRABCD'S); assess scene and alert EMS.
  - Give the oxygen use statement, "This is oxygen, may I help you?" If the casualty does not respond, assume permission is granted.

- ❋ Protect the casualty's *lifeline* as this takes priority over emergency oxygen.
- If the casualty resumes breathing, switch from BVM to a simple mask or non re-breather mask.
- Always make a note of the time you begin providing oxygen and give this information to EMS. If you must stop providing oxygen before EMS arrives, provide both the start and stop times for oxygen administration.

Note: While one emergency responder assembles the emergency oxygen equipment, another can begin providing rescue breaths and CPR.

Note: Regular and repeated practice with this equipment is required to maintain the skill level of the operator. If you have not practiced with this equipment recently and you find yourself in the position of having to treat a non-breathing casualty, provide rescue breaths with supplemental oxygen and a pocket mask.

Note: Ventilation with this equipment is better with two trained operators.

Critical Steps – BAG-VALVE-MASK

- Assemble the emergency oxygen system with a Bag-Valve-Mask.
  - Attach the oxygen tubing to the resuscitation bag inlet
  - Connect the oxygen tubing to the barbed outlet on the regulator
  - Start the flow of emergency oxygen by slowly opening the cylinder valve; make sure the flow controller is set at the "0" or off position.
  - Turn on the flowmeter to 10 lpm and listen for the flow of oxygen
  - Self test the mask by putting your hand over the mask and feel for oxygen flow
  - Check the cylinder pressure gauge.
  - Check for system leaks.
- Place mask over casualty's face, covering the mouth and nose, and hold mask firmly in place, ensuring a good seal – remember positioning!
- Open the casualty's airway with both hands using head tilt-chin lift.
- Carefully give the casualty two rescue breaths by squeezing the resuscitation bag until the casualty's chest rises, then release (approximately 1 second)
  - If you cannot make the casualty's chest rise with the first ventilation, repeat the head tilt-chin lift to open the airway before attempting other ventilations
  - Continue to observe the casualty for regurgitation
  - Check the pressure gauge regularly.