

FExNet 2026

Collated SAQs: Clinical Chemistry and Acid-Base

QUESTION BOOKLET

20 short-answer questions covering the ACEM Fellowship clinical chemistry and acid-base curriculum — arterial and venous blood gas interpretation with worked calculations (Winter's formula, delta ratio, anion gap with albumin correction, osmolar gap, glucose-corrected sodium, A-a gradient, albumin-corrected calcium); electrolyte emergencies; diabetic emergencies (DKA, HHS, euglycaemic DKA); renal replacement therapy; acute liver injury. Stems are written in detailed prose with abbreviations spelt out in full on first use; sub-questions labelled a) b) c) state the required number of responses.

20 questions • 230 marks

ACEM-aligned format. Sub-questions labelled a) b) c). Mark allocations indicative; references cited in the Answer Booklet. Question and answer indexes are clickable.

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Question 1 | Mixed Acid-Base in the Alcoholic with Pancreatitis and Hyperglycaemia (14 marks)

A 41-year-old man with a long history of alcohol use disorder is brought to your emergency department with severe epigastric abdominal pain, intractable vomiting, and progressive lethargy. He last drank alcohol 36 hours ago. On arrival his vital signs are: heart rate 118 beats per minute, blood pressure 100/65 millimetres of mercury, respiratory rate 28 breaths per minute (deep), peripheral oxygen saturation 96 percent on room air, temperature 36.8 degrees Celsius. His arterial blood gas (room air, fraction of inspired oxygen 0.21) and biochemistry are: pH 7.17 (7.35-7.45); pCO₂ 30 mmHg (35-45); pO₂ 98 mmHg; bicarbonate 11 mmol/L (22-32); sodium 117 mmol/L (135-145); potassium 3.5 mmol/L; chloride 64 mmol/L (98-108); glucose 34.2 mmol/L; lactate 8.1 mmol/L (0.5-2.2); ionised calcium 0.74 mmol/L (1.15-1.32); albumin 28 g/L.

a) Calculate the anion gap, expected pCO₂ (Winter's formula), delta ratio, and glucose-corrected sodium AND state the overall acid-base interpretation. (6 marks)

b) List 4 contributing causes for the metabolic derangement. (4 marks)

c) State 4 immediate management priorities (drugs, doses, end-points). (4 marks)

Question 2 | Severe Combined Metabolic and Respiratory Acidosis (12 marks)

A 17-year-old female is brought to your emergency department by ambulance, found drowsy and agitated by her friends. She was last seen well 4 hours ago. Her Glasgow Coma Score is 8. Her vital signs are: heart rate 130 beats per minute, blood pressure 95/55 millimetres of mercury, respiratory rate 14 breaths per minute (shallow), peripheral oxygen saturation 92 percent on room air, temperature 37.5 degrees Celsius. Her electrocardiogram shows sinus tachycardia with right axis deviation and a QRS duration of 140 milliseconds. Her arterial blood gas (room air) and biochemistry: pH 6.90 (7.35-7.45); pCO₂ 70 mmHg (35-45); pO₂ 60 mmHg; bicarbonate 8 mmol/L (22-32); sodium 136 mmol/L; potassium 4.0 mmol/L; chloride 90 mmol/L; lactate 9 mmol/L; glucose 5.5 mmol/L.

a) Calculate the anion gap, expected pCO₂, AND interpret the acid-base disorder. (4 marks)

b) List 4 toxicological causes that could produce this picture in a 17-year-old female. (4 marks)

c) State 4 management priorities specific to tricyclic antidepressant toxicity. (4 marks)

Question 3 | Severe Hypokalaemic Normal Anion Gap Metabolic Acidosis (11 marks)

A 30-year-old man presents to your emergency department with a 24-hour history of progressive weakness affecting all limbs. He has had no preceding illness, no diarrhoea, and no other symptoms. His past medical history is unremarkable. On examination, he has flaccid quadriparesis (Medical Research Council 2/5) with preserved cranial nerves and reflexes. Vital signs: heart rate 110 beats per minute (frequent ectopy), blood pressure 110/70 millimetres of mercury, respiratory rate 26 breaths per minute. His arterial blood gas and electrolytes are: pH 7.26 (7.35-7.45); pCO₂ 29 mmHg; pO₂ 101 mmHg; bicarbonate 13 mmol/L (22-32); sodium 137 mmol/L; potassium 1.8 mmol/L (3.5-5.0); chloride 116 mmol/L; creatinine 86 µmol/L; creatine kinase 1975 U/L.

a) Calculate the anion gap, expected pCO₂ AND interpret the acid-base picture. (5 marks)

b) List 3 immediate management priorities for severe hypokalaemia. (3 marks)

c) List 3 differential diagnoses for normal anion gap metabolic acidosis (USED CARP mnemonic). (3 marks)

Question 4 | Euglycaemic Diabetic Ketoacidosis on SGLT2 Inhibitor (12 marks)

A 78-year-old woman presents to your tertiary hospital emergency department with nausea, vomiting, loose bowel motions, and malaise for 48 hours. Her past medical history includes atrial fibrillation, hypertension, and type 2 diabetes mellitus. Her current medications include candesartan 16 mg daily, apixaban 2.5 mg twice daily, dapagliflozin 10 mg daily, lercanidipine, bisoprolol, simvastatin, and linagliptin-metformin 2.5 mg / 1 g twice daily. On arrival her vital signs are: heart rate 90 beats per minute (irregular), blood pressure 141/72 millimetres of mercury, respiratory rate 28 breaths per minute (deep), peripheral oxygen saturation 93 percent on room air, temperature 35.2 degrees Celsius. Her arterial blood gas and biochemistry: pH 7.35 (7.35-7.45); pCO₂ 24 mmHg (32-48); pO₂ 86 mmHg; bicarbonate 3 mmol/L; sodium 132 mmol/L; potassium 6.4 mmol/L; chloride 102 mmol/L; glucose 15.7 mmol/L (3.0-7.8); lactate 15.0 mmol/L (0.5-2.2); urea 14.6 mmol/L; creatinine 237 µmol/L (40-90).

- a)** Calculate the anion gap, expected pCO₂, delta ratio, AND interpret the acid-base disturbance. (5 marks)

- b)** Explain the mechanism of euglycaemic DKA in patients taking SGLT2 inhibitors. (3 marks)

- c)** State 4 immediate management priorities. (4 marks)

Question 5 | Diabetic Ketoacidosis with Acute Respiratory Failure (14 marks)

Your registrar calls you to the resuscitation bay to help with an 18-year-old male (body weight 80 kilograms) who has been brought in by ambulance with a one-day history of abdominal pain, vomiting, and polyuria following a missed insulin dose. He had a 5-minute generalised tonic-clonic seizure on arrival and was intubated for airway protection. He is currently sedated and mechanically ventilated, awaiting intensive care unit review. His arterial blood gas (with fraction of inspired oxygen 1.0): pH 7.02 (7.35-7.45); pCO₂ 60 mmHg (35-45); pO₂ 200 mmHg; bicarbonate 11 mmol/L; sodium 125 mmol/L; potassium 6.5 mmol/L; chloride 86 mmol/L; glucose 35 mmol/L; lactate 2.5 mmol/L; haemoglobin 155 g/L.

a) Complete the table — for each variable, state the formula, calculate the result, AND give the clinical implication. (8 marks)

b) State the diagnosis AND list 2 likely causes for respiratory acidosis. (3 marks)

c) State 3 ventilation strategies to manage this patient with severe metabolic acidosis. (3 marks)

Question 6 | Severe Hyperkalaemia in End-Stage Renal Disease (12 marks)

A 67-year-old man is brought to your emergency department by his family after he collapsed at home. His past medical history includes haemodialysis-dependent end-stage renal disease (secondary to diabetic nephropathy), hypertension, ischaemic heart disease, and congestive cardiac failure. He missed his dialysis session 4 days ago. On arrival his vital signs are: Glasgow Coma Score 15, blood pressure 80/50 millimetres of mercury, heart rate 80 beats per minute, respiratory rate 30 breaths per minute, peripheral oxygen saturation 90 percent on room air. Bedside venous blood gas: pH 7.20, pCO₂ 28, bicarbonate 11, sodium 140, potassium 7.8, chloride 105, glucose 6.5, lactate 4.0. Electrocardiogram shows tall peaked T waves with broad P-waves and prolonged PR interval.

a) List 4 electrocardiographic abnormalities evolving with progressive hyperkalaemia. (4 marks)

b) Complete the table — list 3 management options with mechanism, dose, and target endpoint. (6 marks)

c) List 2 immediate priorities for this haemodynamically unstable dialysis patient (other than potassium correction). (2 marks)

Question 7 | Severe Symptomatic Hyponatraemia with Seizure (12 marks)

A 24-year-old man is brought to your emergency department by friends after participating in a marathon endurance event. He reported drinking large quantities of water during the race. Following the event, he developed progressive confusion, headache, and a 2-minute generalised tonic-clonic seizure in the ED. His vital signs: heart rate 110 beats per minute, blood pressure 120/85 millimetres of mercury, respiratory rate 22 breaths per minute, peripheral oxygen saturation 98 percent on room air, temperature 36.0 degrees Celsius, Glasgow Coma Score 12 post-ictal. His urgent biochemistry shows: sodium 109 mmol/L (135-145), potassium 4.1 mmol/L, chloride 91 mmol/L, bicarbonate 22 mmol/L, glucose 10 mmol/L, urea 4.5 mmol/L, plasma osmolality 230 mOsm/kg (275-295).

a) Categorise this hyponatraemia (3 features) AND calculate calculated osmolality. (3 marks)

b) State 5 immediate management steps with drug, dose, and end-point. (5 marks)

c) List 4 risk factors for osmotic demyelination syndrome (ODS). (4 marks)

Question 8 | Paediatric Diabetic Ketoacidosis — Calculation Formulae (12 marks)

A 13-year-old girl (estimated weight 45 kilograms) presents to your emergency department with confusion and abdominal pain. She has a known background of type 1 diabetes mellitus requiring insulin treatment (missed insulin for 24 hours after gastroenteritis). She has had 3 days of vomiting and 2 days of diarrhoea. Her vital signs: heart rate 124 beats per minute, blood pressure 120/70 millimetres of mercury, respiratory rate 30 breaths per minute (deep, Kussmaul), peripheral oxygen saturation 99 percent on room air, central capillary refill time 4 seconds, temperature 37 degrees Celsius. Initial venous blood gas: pH 6.93 (7.35-7.45); pCO₂ 9 mmHg; pO₂ 44.9 mmHg; bicarbonate 2 mmol/L; base excess -25.5 mmol/L; sodium 124 mmol/L; potassium 6.2 mmol/L; chloride 79 mmol/L; glucose 43.5 mmol/L; haemoglobin 162 g/L.

a) Quote 6 relevant formulae for analysis of this blood gas WITH calculated values. (6 marks)

b) State 6 principles of fluid and electrolyte treatment with rationale per current ANZICS / ISPAD paediatric DKA guidance. (6 marks)

Question 9 | Salicylate Overdose — Mixed Acid-Base Disorder (12 marks)

A 35-year-old woman is brought to your emergency department by ambulance after her husband found her confused with several empty packets of aspirin. He estimates she may have ingested up to 30 grams of aspirin approximately 6 hours ago. On arrival, she is diaphoretic, tinnitus-affected, with a respiratory rate of 36 breaths per minute (deep). Her vital signs: heart rate 130 beats per minute, blood pressure 110/68 millimetres of mercury, peripheral oxygen saturation 99 percent on room air, temperature 38.5 degrees Celsius. Her arterial blood gas: pH 7.38 (7.35-7.45); pCO₂ 16 mmHg; bicarbonate 9 mmol/L; sodium 138 mmol/L; potassium 3.8 mmol/L; chloride 100 mmol/L; lactate 3.0 mmol/L; salicylate level 870 mg/L (toxic >300, lethal >700).

- a)** Calculate the anion gap, expected pCO₂, AND interpret the acid-base. (4 marks)

- b)** State 4 management priorities specific to salicylate toxicity. (4 marks)

- c)** List 4 features of severe salicylate toxicity. (4 marks)

Question 10 | Toxic Alcohol — Osmolar Gap and Anion Gap (11 marks)

A 45-year-old man with a long history of alcohol use disorder is brought to your emergency department by his partner after she found him confused, vomiting, and complaining of blurred vision. He had no access to ethanol over the past day but was found with an open container of windshield wash fluid. His vital signs: heart rate 120 beats per minute, blood pressure 105/65 millimetres of mercury, respiratory rate 28 breaths per minute, temperature 36.5 degrees Celsius. His arterial blood gas and biochemistry: pH 7.20 (7.35-7.45); pCO₂ 22 mmHg; bicarbonate 8 mmol/L; sodium 142 mmol/L; potassium 4.5 mmol/L; chloride 100 mmol/L; glucose 6 mmol/L; urea 5 mmol/L; lactate 1.2 mmol/L; ethanol <0.05 (undetectable). Measured serum osmolality 360 mOsm/kg.

a) Calculate the anion gap, calculated osmolality, AND osmolar gap. (4 marks)

b) List 4 management priorities for suspected methanol or ethylene glycol toxicity. (4 marks)

c) List 3 features distinguishing methanol from ethylene glycol poisoning. (3 marks)

Question 11 | Acute Liver Failure — Paracetamol Toxicity (12 marks)

A 26-year-old woman is brought to your emergency department after being found unconscious in her bed at home. She has not been seen for 2 days. Her biochemistry on arrival is: Sodium 135 mmol/L; potassium 4.5 mmol/L; chloride 100 mmol/L; bicarbonate 2 mmol/L; urea 5.8 mmol/L; creatinine 160 μ mol/L (60-110); total protein 50 g/L; albumin 30 g/L; globulin 20 g/L. Liver function tests: bilirubin 77 μ mol/L (<20); ALP 143 U/L; gamma GT 328 U/L (<55); ALT 8050 U/L (<45); AST 7560 U/L (<35). INR 5.8 (unmeasurable). Lactate 7.5 mmol/L. Glucose 2.5 mmol/L. Paracetamol level pending.

a) State 4 abnormalities AND their pathophysiological basis. (4 marks)

b) List 4 differential diagnoses for ALT >5000 U/L. (4 marks)

c) State 4 management priorities including specific antidote. (4 marks)

Question 12 | Triple Acid-Base Disorder — Pancreatitis with Vomiting and Hypoperfusion (12 marks)

A 45-year-old man with a long history of alcohol use presents to your emergency department with intractable vomiting for 36 hours. He last drank alcohol 18 hours ago and reports severe epigastric pain radiating to his back. On examination he is diaphoretic with epigastric tenderness. Vital signs: heart rate 105 beats per minute, blood pressure 105/65 millimetres of mercury, respiratory rate 28 breaths per minute, peripheral oxygen saturation 98 percent on room air, temperature 37.5 degrees Celsius. His venous blood gas: pH 7.61 (7.35-7.45); pCO₂ 19 mmHg; bicarbonate 18 mmol/L; sodium 137 mmol/L; potassium 3.7 mmol/L; chloride 98 mmol/L; ionised calcium 1.03 mmol/L (1.15-1.32); glucose 4.8 mmol/L; lactate 8.5 mmol/L.

a) Calculate the anion gap and expected pCO₂ (considering all 3 disorders) AND interpret. (5 marks)

b) List 4 likely contributors to the lactic acidosis. (4 marks)

c) List 3 management priorities specific to this presentation. (3 marks)

Question 13 | Severe Uraemic Acidosis (11 marks)

A 32-year-old Aboriginal woman presents to your emergency department with a 2-week history of lethargy, nausea, and decreased urine output. She is previously well and has not been seen by medical services for 10 years. Her vital signs: heart rate 95 beats per minute, blood pressure 165/100 millimetres of mercury, respiratory rate 26 breaths per minute, peripheral oxygen saturation 96 percent on room air. Her venous blood gas and biochemistry: pH 7.20 (7.35-7.45); pCO₂ 28 mmHg; bicarbonate 11 mmol/L; sodium 132 mmol/L; potassium 6.5 mmol/L; chloride 96 mmol/L; urea 62 mmol/L; creatinine 1842 µmol/L (40-90); haemoglobin 76 g/L; calcium 1.6 mmol/L; phosphate 3.5 mmol/L.

- a)** Calculate the anion gap, expected pCO₂, AND interpret the acid-base. (5 marks)

- b)** List 4 likely causes of chronic kidney disease in this 32-year-old Aboriginal woman. (4 marks)

- c)** State 2 immediate management priorities (with drug, dose). (2 marks)

Question 14 | Severe Metabolic Alkalosis with Hypokalaemia (10 marks)

A 40-year-old man with a developmentally delayed background is brought to your emergency department by his carers with vomiting. He had a percutaneous endoscopic gastrostomy (PEG) inserted 4 weeks ago for feeding; ongoing reflux and vomiting have led to estimated 3-week persistent vomiting. He weighs approximately 40 kilograms. On arrival his Glasgow Coma Score is 13 (his baseline per carers). Vital signs: heart rate 90 beats per minute, blood pressure 140/70 millimetres of mercury, respiratory rate 13 breaths per minute, peripheral oxygen saturation 95 percent on room air. His venous blood gas and biochemistry: pH 7.55 (7.35-7.45); pCO₂ 50 mmHg; bicarbonate 42 mmol/L; sodium 145 mmol/L; potassium 2.0 mmol/L (3.5-5.0); chloride 88 mmol/L; ionised calcium 1.02 mmol/L; glucose 7.4 mmol/L.

- a)** Calculate expected pCO₂ for primary metabolic alkalosis AND interpret the acid-base. (4 marks)

- b)** Describe the relationship between alkalosis and hypokalaemia AND quantify expected K shift with alkalosis correction. (3 marks)

- c)** State 3 management priorities with drug, dose, and monitoring. (3 marks)

Question 15 | Diabetic Ketoacidosis with Hyperosmolar Features (13 marks)

A 60-year-old man with a past history of type 2 diabetes mellitus is brought to your emergency department by his elderly mother who found him collapsed on the floor. He has been unwell with vomiting for the past 3 weeks and has not been eating. His vital signs: blood pressure 65/30 millimetres of mercury, heart rate 120 beats per minute (regular), respiratory rate 36 breaths per minute (deep, Kussmaul), peripheral oxygen saturation 100 percent on 15 litres oxygen via non-rebreather mask, Glasgow Coma Score 13. His venous blood gas: pH 6.91 (7.35-7.45); pCO₂ 13 mmHg; bicarbonate 4 mmol/L; sodium 106 mmol/L; potassium 6.3 mmol/L; chloride 73 mmol/L; glucose 82 mmol/L (3-7); lactate 3.1 mmol/L; urea 32 mmol/L; creatinine 280 µmol/L.

a) Calculate anion gap, corrected sodium, expected pCO₂, AND calculated osmolality. (5 marks)

b) List 5 immediate management priorities. (5 marks)

c) State 3 ventilation considerations if intubation becomes necessary. (3 marks)

Question 16 | Severe Hypocalcaemia in Chronic Pancreatitis (10 marks)

A 62-year-old male with a long history of chronic alcohol-related pancreatitis presents to your emergency department with several days of nausea, vomiting, and intermittent muscle spasms. On examination he has positive Chvostek's and Trousseau's signs, peri-oral tingling, and intermittent carpopedal spasm. He is otherwise haemodynamically stable. His biochemistry: Total calcium 1.50 mmol/L (2.10-2.55); ionised calcium 0.78 mmol/L (1.15-1.32); albumin 28 g/L; magnesium 0.42 mmol/L (0.7-1.0); phosphate 2.0 mmol/L; potassium 3.0 mmol/L; ALT 60; lipase 850 U/L. Electrocardiogram shows prolonged QT interval (corrected QT 510 ms).

- a)** Calculate the albumin-corrected calcium AND comment on the difference from ionised calcium. (3 marks)

- b)** List 4 clinical features of severe hypocalcaemia. (4 marks)

- c)** State 3 management priorities including drug, dose, and end-points. (3 marks)

Question 17 | Acute Adrenal Insufficiency (10 marks)

A 45-year-old man with known autoimmune Addison's disease (taking long-term hydrocortisone 20 mg orally daily) presents to your emergency department with 5 days of vomiting, severe abdominal pain, and lethargy. He stopped taking his hydrocortisone 3 days ago because he was unable to keep oral intake. His vital signs: heart rate 130 beats per minute, blood pressure 70/40 millimetres of mercury, respiratory rate 28 breaths per minute, peripheral oxygen saturation 95 percent on room air, temperature 35.5 degrees Celsius. His venous blood gas and biochemistry: pH 7.30 (7.35-7.45); pCO₂ 26 mmHg; bicarbonate 12 mmol/L; sodium 122 mmol/L; potassium 6.4 mmol/L; chloride 96 mmol/L; glucose 2.8 mmol/L; lactate 5.2 mmol/L; calcium 2.6 mmol/L (raised).

a) List 4 biochemical abnormalities with explanation. (4 marks)

b) State 4 immediate management priorities. (4 marks)

c) List 2 sick-day rules for patients with Addison's disease. (2 marks)

Question 18 | Metformin-Associated Lactic Acidosis (10 marks)

A 75-year-old man with type 2 diabetes mellitus (treated with metformin 1 g twice daily and gliclazide), chronic kidney disease (estimated glomerular filtration rate 30 millilitres per minute), and chronic heart failure presents with 3 days of vomiting, diarrhoea, and progressive lethargy. His vital signs: heart rate 110 beats per minute, blood pressure 95/55 millimetres of mercury, respiratory rate 28 breaths per minute, peripheral oxygen saturation 95 percent on room air, temperature 36.0 degrees Celsius. His biochemistry: pH 7.10 (7.35-7.45); pCO₂ 25 mmHg; bicarbonate 10 mmol/L; sodium 138 mmol/L; potassium 5.5 mmol/L; chloride 102 mmol/L; glucose 6.5 mmol/L; lactate 12.5 mmol/L; urea 22 mmol/L; creatinine 350 µmol/L.

a) Calculate the anion gap, expected pCO₂, AND interpret the acid-base. (4 marks)

b) State 4 management priorities. (4 marks)

c) List 2 contraindications to metformin. (2 marks)

Question 19 | Rhabdomyolysis (10 marks)

A 28-year-old man is brought to your emergency department after collapsing during the 35-kilometre mark of a marathon on a hot summer day (ambient temperature 38 degrees Celsius). He has been drinking water but feels thirsty. On arrival, his vital signs: heart rate 130 beats per minute, blood pressure 95/60 millimetres of mercury, respiratory rate 28 breaths per minute, peripheral oxygen saturation 96 percent on room air, temperature 40.5 degrees Celsius (rectal). He passes dark, tea-coloured urine on catheterisation. Biochemistry: Sodium 142 mmol/L; potassium 6.8 mmol/L; chloride 98 mmol/L; bicarbonate 14 mmol/L; urea 14 mmol/L; creatinine 220 µmol/L; calcium 1.8 mmol/L; phosphate 3.0 mmol/L; creatine kinase 75,000 U/L (<200); urinalysis: blood +++ (no red cells on microscopy — myoglobin).

a) Define rhabdomyolysis AND state 3 biochemical abnormalities expected. (3 marks)

b) State 4 immediate management priorities. (4 marks)

c) List 3 causes of rhabdomyolysis. (3 marks)

Question 20 | Rapid Arterial Blood Gas Interpretation Series (10 marks)

Below are 5 arterial blood gases drawn from 5 different patients in your emergency department. For each, calculate the anion gap (where applicable), expected pCO₂ (Winter's formula or appropriate compensation rule), AND state the most likely primary disorder.

- a)** Patient A: pH 7.10, pCO₂ 60, bicarbonate 18, Na 138, K 5.0, Cl 100. State the disorder. (2 marks)

- b)** Patient B: pH 7.55, pCO₂ 50, bicarbonate 42, Na 140, K 3.0, Cl 88. State the disorder. (2 marks)

- c)** Patient C: pH 7.35, pCO₂ 28, bicarbonate 14, Na 142, K 4.0, Cl 102, lactate 6. State the disorder. (2 marks)

- d)** Patient D: pH 7.42, pCO₂ 50, bicarbonate 32. State the disorder (consider chronic). (2 marks)

- e)** Patient E: pH 7.30, pCO₂ 30, bicarbonate 14, Na 134, K 4.5, Cl 113, glucose 22. State the disorder. (2 marks)
